LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

LEVEL

0

INVENTORY

DTIC ACCESSION NUMBER

BIRD STRIKE COMMITTEE EUROPE (BSCE) 10th MEETING - 1975

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR
NTIS GRA&I
DTIC TRAC
UNANNOUNCED
JUSTIFICATION

BY
DISTRIBUTION/
AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

19990910 078

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

H A N D L E W I T H C A R E

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	1975	Conference Proceeding 9-13 June 1975

4. TITLE AND SUBTITLE
Bird Strike Committee Europe (BSCE) , 10th Meeting, Stockholm, Sweden
9th - 13th June 1975

5. FUNDING NUMBERS

6. AUTHOR(S)
Bird Strike Committee Europe

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Bird Strike Committee Europe

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Bird Strike Committee Europe

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copyright waived per email from Willemijn Prast, Sent: Wednesday, September 01, 1999,
To: Short, Jeffrey, USAF IBSC Representative, Tyndall AFB, FL 32403.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE
A

13. ABSTRACT (Maximum 200 words)
The Bird Strike Committee Europe consists of civil and military participants from Europe with a common interest in the bird strike problem. Attendance is open to participants from other parts of the world. Annual Meeting Proceedings include Chairman's Report, Working Group Reports and Papers Presented:

TABLE OF CONTENTS:

14. SUBJECT TERMS
Bird Strikes, Aviation Safety, Airports, Hazards, Survivability, BSCE, International Bird Strike Committee, IBSC

15. NUMBER OF PAGES
286

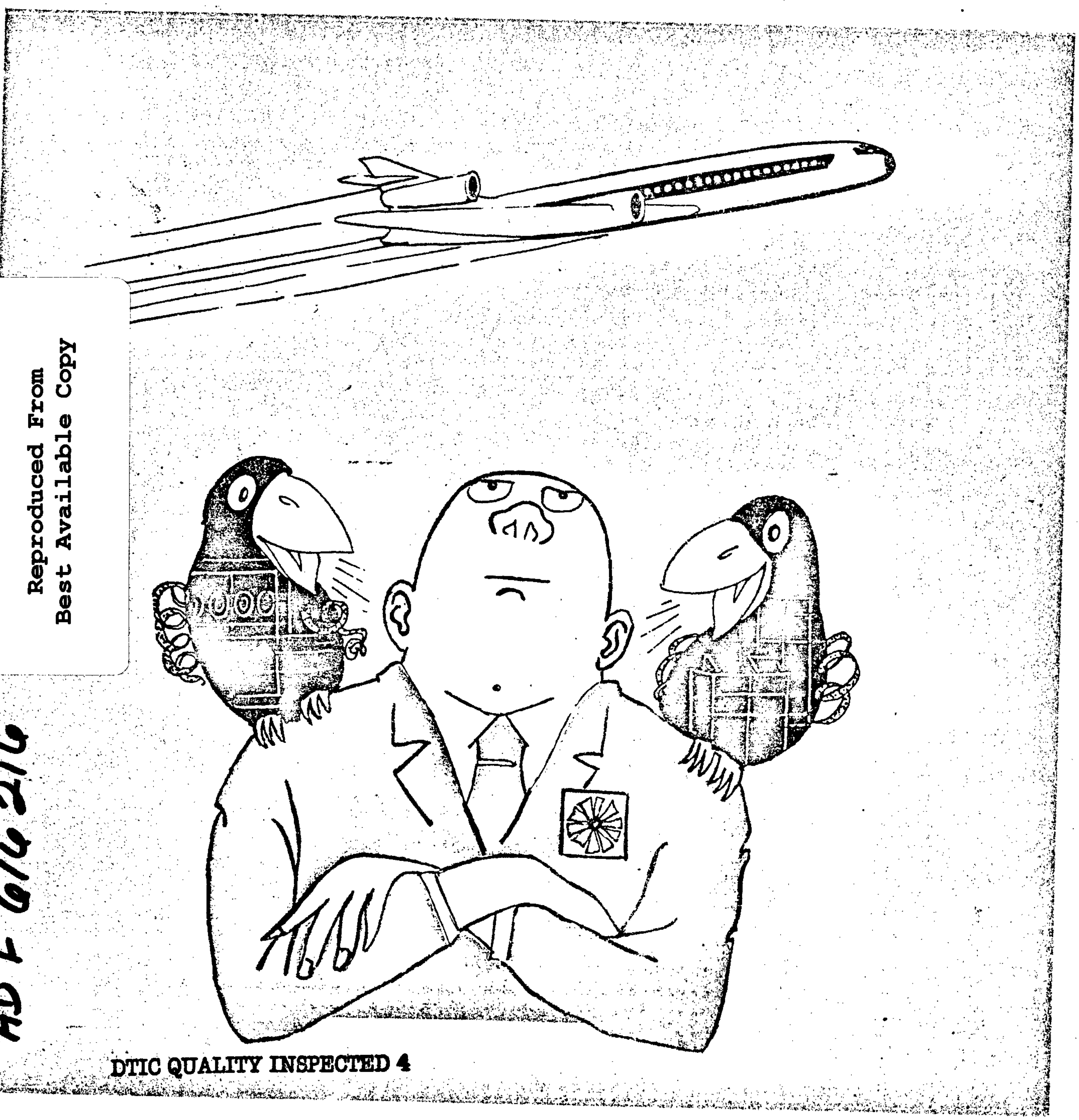
16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19, SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

10th Meeting

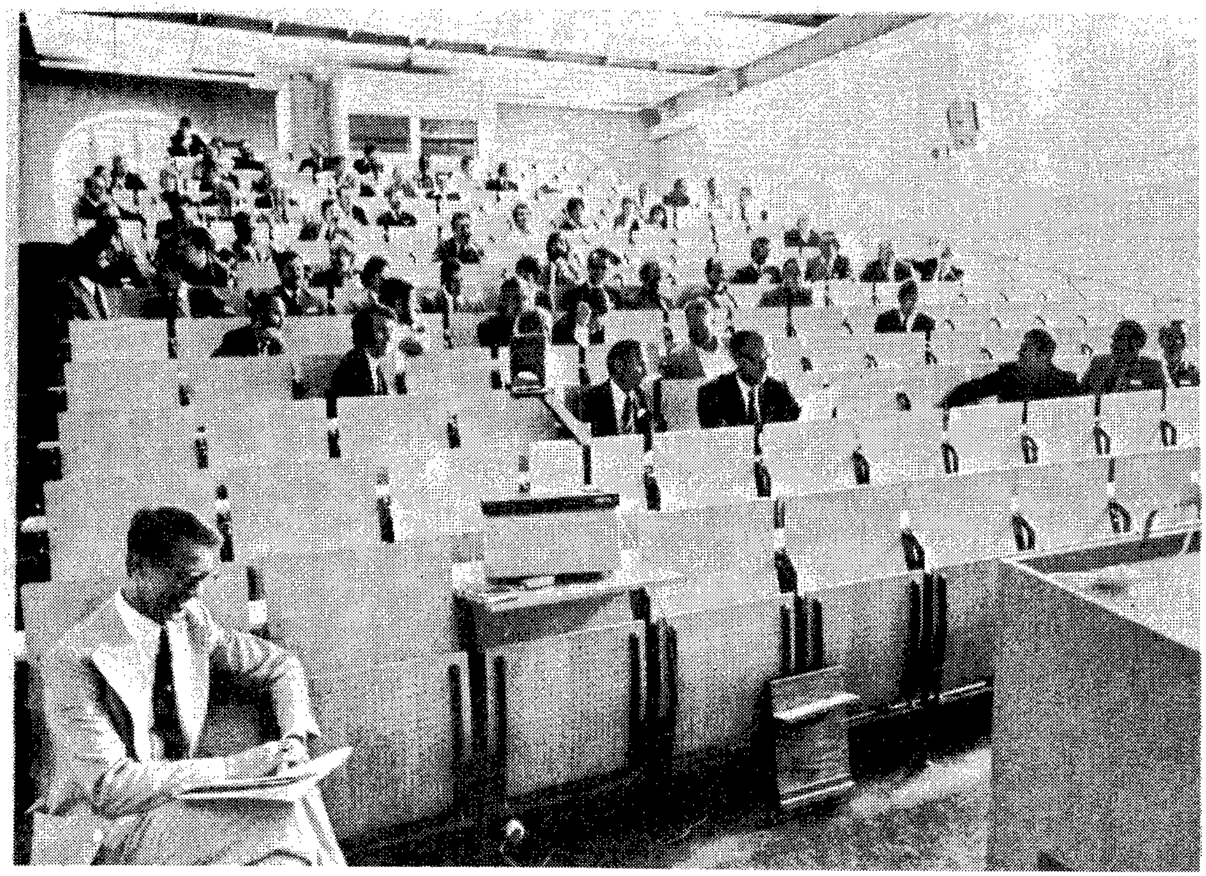
Bird Strike Committee Europe

BSCE



Stockholm 9th - 13th june 1975

Table of contents

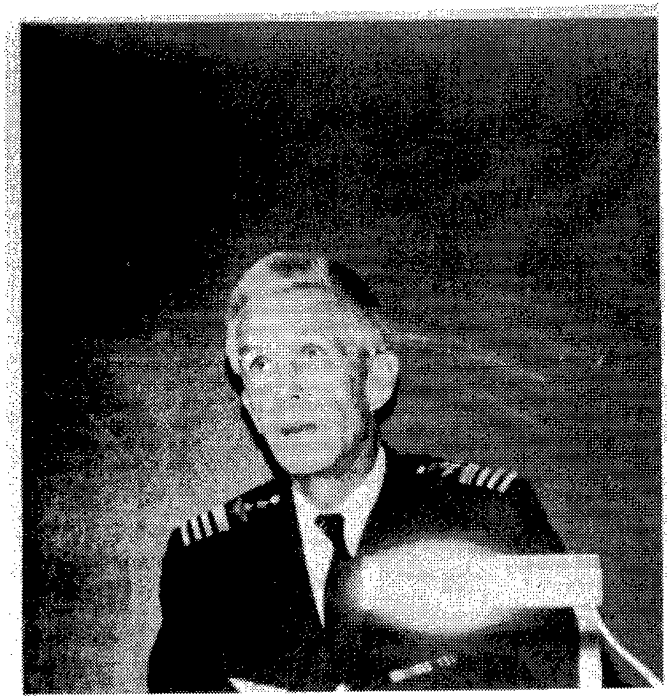


Room for the Plenary Meeting

In the foreground, left, Mr F. Görs, acting Director General of the Swedish Board of Civil Aviation, after his opening speech.

The Board of the Meeting

From the left: Mr L.-O. Turesson, Sweden, secretary, Mr V. E. Ferry, France, chairman and Major B. Nåsell, Sweden, secretary. In the platform Dr J. Hild, West Germany, delivering the report of Working Group Bird Movements.



Brig.Gen. B. Hedberg, Royal Swedish Airforce delivering the closing speech of the Meeting.

From the excursion in the Stockholm Archipelago

Left to right: Messrs E. W. Houghton, UK, T. Brough, UK and T. Alerstam, Sweden.

1. Recommendations

A. Based on work of Bird Movement W.G.

B. Based on work of Communications W.G.

C. Based on work of Aerodromes W.G.

D. Based on work of Analysis W.G.

E. Based on work of Radar W.G.

F. Related to work to be undertaken by a Structural Testing W.G.

12 June 1975

RECOMMENDATIONS

The Bird Strike Committee Europe recommends:

A) Based on work of Bird Movement W.G.

No. 1: Bird Hazard maps should be published in the AIP of each State.

No. 2: Revised bird hazard maps to be published in near future must be sent by each State representative before 31 December 1975 to W.G. chairman.

No. 3: The Working Group should coordinate bird hazard maps printed in each State.

No. 4: The Working Group is undertaking the task to evaluate the bird risk in large areas in terms of biomass. Proposal should be sent as soon as possible to W.G. chairman.

B) Based on work of Communications W.G.

No. 1: A period of one week in length should be selected in October 1975 to test the whole system after amendments agreed upon during the 10th meeting. Weak points have to be eliminated whenever possible

No. 2: The address list should be checked and completed, when necessary. Its publication is requested as soon as possible.

No. 3: The phraseology approved by the Group should be used for trial evaluation.

C) Based on work of Aerodromes W.G.

No. 1: Each State shall send the technical specifications of all currently used bird dispersal devices to the chairman of the W.G. The chairman will consolidate the information and distribute it to the W.G.

No. 2: Each state shall provide local and national regulations applying to garbage dumps and to controllable bird movements (e.g. racing pigeons).

No. 3: Each State should incorporate on the bird strike reporting form the following item:

Were lights being used:

- Landing lights Yes ☐ No ☐
- Strobe light Yes ☐ No ☐

D) Based on work of Analysis W.G.

1. That those European countries which did not provide analyses using the BSCE layout should again be requested to provide the information.

   Note: The countries concerned are Germany, Italy and Norway.

2. That the Authorities responsible for civil airports with above average strike rates should be informed, and asked to investigate and take appropriate action.

3. That the available evidence which indicates differing abilities of various parts of civil aircraft including intakes end engines to withstand birdstrikes, should be further investigated.

4. That every effort should be made to obtain the cost of engineering repairs caused by bird strikes on Civil Aircraft.

5. That all European air forces should be approached at the appropriate level by the BSCE Chairman in order that security will allow the use of both movement and strike rate information. Each delegation should give this appropriate name and address to the BSCE Chairman.

6. That information should be provided to the United States NTSB as the BSCE contribution to their current survey on bird ingestions by large fan engines.

7. That the Aerodromes W.G. resolution on the reporting of the use of lights is fully endorsed.

E) Based on work of Radar W.G.

A paper relating obtained radardata and bird strike probability should be prepared and sent to appropriate members of each State participating in BSCE for consideration an comment. One member has been elected as focal point for this task.

Note: Comments will be specifically requested from air crew, air traffic and flight safety officers.

F) Related to work to be undertaken by a Structural Testing W.G.

1. It is proposed that a new Working Group be formed called the "Information on Structural Testing of Airframes Working Group".

2. The terms of reference were proposed as follows:

   (i) To exchange information on the results obtained from:

      (a) Bird impact research testing of materials, structural specimens, windscreens etc.

(b) Tests to meet compliance with Civil Airworthiness requirements.

(ii) To discuss and evaluate the information in order to provide design guidance material for satisfactory methods of producing bird impact resistant structures, windscreens etc.

(iii) To exchange information on analytical work.

(iv) To establish liason on future research programmes in order to avoid duplication.

3. It is proposed that there should be a meeting of the new Working Group in London in approx. 6 months time. During the next 6 months Mr. Thorpe will invite the appropriate specialists in BSCE member countries to attend this meeting where a chairman will be appointed.

These recommendations have been discussed during the plenary session and have been adopted by the Committee. They will be in force starting 1 July 1975.

2. List of participants

Name	Profession/Rank	Organization, Address
Belgium		
Boomans, J F	Senior Meteorologist	Meteorological Wing Belgian Air Force 86 Lange Eikstraat 1970 - Wezembeek
Heirman, J	Biologist	Centrum voor Bosbiologie Bokzyk 3600 Genk
Jacobs, T	Chief Controller	Belgian Air Force CRP Semmerz 9740 Gavere
Soetens, C	Programmer	Seros Molenstraat 7 9740 Gavere
Denmark		
Clausen, P R	Officer	Air Force ESK 502, FSN Stensved 4773 Stensved
Dahl, H	Head of Office	Directorate of Civil Aviation 60 Gl Kongevej 1850 Copenhagen
Glennung, A M	Airport Controller	Copenhagen Airport Authority 2770 Kastrup
Holm-Joensen, A	Dr Phil	Game Biology Station, Kalø 8410 Rønde
Lind, H	Dr	University of Copenhagen Zoological Laboratory Universitetsparken 15 2100 Copenhagen
Schneider, E P	Lt Col	Air Force Air Station Skrydstrup 6500 Vojens
Sørensen, K	Captain Flight Safety	TACDEN HQ Tactical Air Command 7470 Karup

Name	Profession/Rank	Organization, Address
Finland		
Salonen, K	Insp Flight Operations	National Board of Civil Aviation Flight Safety Department Siltasaarenkatu 12A 00510 Helsinki 51
France		
Attig	Adm Officer	Inspection Generale de l'Aviation Civile 246 Rue Lecombe, Paris
Briot, J L	Biologist	SGAC Service Technique de la Navigation Aérienne 246 Rue Lecourbe 75015 Paris
Ferry, V E	Ing	Direction des Transports Aériens DTA/CM 2 SGAC 93 Bld du Montparnasse 75006 Paris
Laty, M	Biologist	Service Technique de la Navigation Aérienne 155 Rue de la Croix Nivert 75015 Paris
Cesbron-Lavau, H	Captain	FAF GROAA 5 bis Avenue de la Porte de Sèvres 75996 Paris-Armées
Marfaing, R		FAF EMAA/3B/SV 24 Bld Victor 75996 Paris
Mugnier, J P	Ing	Secretariat General a l'Aviation Civile Direction des Transports Aeriens 36 Rue du Louvre Paris
Sonette, J C	Pilot Air France	COMETEC (Technical group) SNPL Cidex A213 94396 Orly-Aerogares

Name	Profession/Rank	Organization, Address
Netherlands		
Buurma, L S	Drs Ornithologist	RNLAF Air Staff - Flight Safety 1e v d Boschstraat 8 Den Haag
Lennarts, A	Lt Col	"
Schoot, M H J		Dep Head of Operations Schiphol Airport Amsterdam
van Wyngaarden, J A		Dep Dutch Civil Aviation Plesmanweg 1-6 Den Haag
Norway		
Pedersen, P W	Air Traffic Insp	Directorate of Civil Aviation Oslo
Vik, R	Professor in Zoology	University of Oslo Sarsgt 1 Oslo 5
Poland		
Luniak, M	Biologist	Institute of Zoology 00-950 Warszawa Box 1007 Wilcza 64

//

Name	Profession/Rank	Organization, Address
Sweden		
Alerstam, T	Ornithologist	University of Lund Dept of Animal Ecology Zoological Institute 223 62 Lund
Arhall, B	Lt	Swedish Airforce F 21 Luleå
Bergqvist, N A	Col	Swedish Airforce Swedish Air Staff 104 50 Stockholm
Brise, S	Director	Skandia Insurance Co Aviation Insurance P O Box 103 60 Stockholm 3
Brolén, P E	Captain Flight Safety Officer	Swedish Airforce F 1 Box 706, Västerås
Dahl, L T	Flight Officer	Linjeflyg AB 161 10 Bromma 10
Duvander, Å	Air Safety Officer	Scandinavian Airlines System 161 87 Bromma
Ehde, M	State Meteorologist	Swedish Meteorological and Hydrological Institute Malmö-Sturup
Enderlein, L	Director	Scandinavian Airlines System 161 87 Bromma
Engström, R	Civ Eng	Board of Civil Aviation Airport Services 161 89 Bromma
Ersbacken, S E	Lt Col	Board of Civil Aviation 161 89 Bromma
Folkinger, E	Staff Meteorologist	Swedish Airforce 104 50 Stockholm
Forsman, L	Photogr	Saab-Scania AB Fack 581 88 Linköping
Fredga, S	Director Wild life management	Swedish Sportmen's Association Box 39049 100 54 Stockholm 39

12

Name	Profession/Rank	Organization, Address
Sweden contd		
Hemberg, D W	Major	Swedish Airforce F 13 600 04 Norrköping
Höjer, C	Head of Information Dept	Board of Civil Aviation 161 89 Bromma
Jönsson, L	ATS-Inspector	"
Karlsson, J	Zooecologist	"
Larsson, B	Meteorologist	Swedish Airforce Kgl Krigsflygskolan 260 70 Ljungbyhed
Larsson, T	Adm Officer	National Environment Protection Board 171 20 Solna
Lindberg, N O	Flight Officer	Swedish Pilots Association Bromma
Mattsson, E	Air Traffic Controller	Board of Civil Aviation 190 45 Stockholm-Arlanda Airport
Nåsell, B	Major Flight Safety	Swedish Airforce 104 50 Stockholm
Näslund, E	Engineer	Saab-Scania AB Fack 581 88 Linköping
Röed, A	Head System Studies and Flight Safety Section	The Aeronautical Research Institute of Sweden Box 11021 161 11 Bromma 11
Sellberg, L D	Head of Office	The Royal Institute of Techn Institute of Aviation Safety 100 44 Stockholm
Sjögren, Å	Lt Col	Swedish Airforce 104 50 Stockholm
Skans, S	Civ Eng	LUTAB Snörmakarvägen 29 161 47 Bromma
Ståhl, L	Captain	Crownair Ltd Fack 161 10 Bromma

13

Name	Profession/Rank	Organization, Address
Sweden contd		
Turesson, L O	Meteorologist	Board of Civil Aviation 161 89 Bromma
Ulfstrand, S	Professor	University of Lund Dept of Animal Ecology 223 62 Lund
Weinberg, U	Head of Office	National Environment Protection Board 171 20 Solna
Wiklund, U	Inspector	Board of Civil Aviation Flight Safety Division 161 89 Bromma
Wisell, G	State Meteorologist	Swedish Meteorological and Hydrological Institute Torslanda Airport Gothenburg
Åkerstedt, C	Airport Manager	Board of Civil Aviation Malmö-Sturup Airport 230 32 Malmö-Sturup
Switzerland		
Bruderer, B	Dr, Zoologist	Schweizer Vogelwarte 6204 Sempach
U.K.		
Brough, T	Scientific Officer	Ministry of Agriculturs Worplesdon, Guildford Surrey
Houghton, E W	Principal Scientific Officer	Royal Radar Establishment MOD(PE) Malvern, Worcs
Lake, H	Squadron Leader	Royal Air Force London
Stokes, B	Flt Lt	HQ RAF Germany
Thorpe, J		Civil Aviation Authority Airworthiness Division Redhill, Surrey

14

Name	Profession/Rank	Organization, Address
West Germany		
Hild, J	Dr Reg Director	German Air Force Office Mil Geophysics P.O.B 5000 1507 5 Cologne 90
Keil, W	Dr	Institute of applied Ornithology Steinauer Str 44 6 Frankfurt/M 61
Kempkens, U	Director	Delvag Luftfahrt Versicherung 2-6 von Goblenz Str 5 Cologne 21
Schabram, W J	Manager Claims Dept	"
Canada		
Blokpoel, H	Scientific Officer	Canadian Wildlife Service 2721 Highway 31 Ottowa
Bosik, A	Research Officer	National Aeronautical Establ National Research Council Montreal Road Ottowa
Carpenter, W J	Major	Canadian Forces Europe 1 Canadian Air Group HQ 763 Lahr West Germany
Hunt, F	Research Officer	National Research Council Radio Division Ottowa
Israel		
Suaretz, S	Chief Ornithologist	Nature Reserves Authority Hannatziv 16 Tel Aviv

/5

Name	Profession/Rank	Organization, Address
USA		
Driscoll, A T	Major	USAF AFISC/SEFF Norton
Seubert, J	Dr Biologist	Patuxent Wildlife Research Center Laurel, Md 20811
Stout, J	Professor	Max Planck Inst für Verholten-physiologie 8131 Seewiesen West Germany
ICAO		
Eigl, C	Adm Officer	ICAO 3 bis Villa Emile Bergerat 92200 Neuilly/Seine France

16

3. <u>Opening speech</u>

Mr F Görs, Sweden, Acting Director General, Swedish Board of Civil Aviation.

Speech at the opening of BSCE/10

Mr Chairman, Ladies and Gentlemen,

It's a great pleasure to wish delegates of 14 states welcome to this Meeting in Stockholm of the Bird Strike Committee Europe. As it is the tenth Meeting, we are celebrating an anniversary, and as you, Mr Chairman, recently has expressed the situation, BSCE is now joining the group of "two digits" organizations. That means yuo are now out of the cradle, and have found good methods for your work.

After having been alone in the airspace for millions of years, the birds have during this century got some competition from man. Collisions between the two types of flying creatures have become unavoidable, especially as only one of the parties is supported by air traffic services.

In fact fatal accidents have been caused by collisions since 1910. But before the age of jet aircrafts the strike were rare, and did seldom damage our air vehicles. With jets the situation changed seriously. The high speed of the aircrafts has made it impossible for the birds to avoid their airspacecompetitors, and they are often ingested into the engines. There they cause damage which is sometimes tremendous. Accidents with loss of lives have occured, three of them with Swedish military aircrafts. And even if the result of a birdstrike will seldom become an accident, the costs of repairs will be considerable. This is why your work has become of such a high importance in the flight safety work.

From the names of the working groups, BSCE and from the titles of the working papers, which are going to be presented here, I can see, that your work with the bird strike problems is covering a great number of different fields: analysis, work in the airport, studies of bird movements, visually and by radar etc. A new working group for "Design of Bird Impact Resistant Airframes" has now started its work and will certainly be of high importance.

Many of the papers are dealing with the airport problems, and how to reduce the birdfrequency. Perhaps I can here specially mention the very interesting trials, which are going on at Nice/Cote d'Azur airport in France, where a resting area for gulls has been created in the outskirts of the airport, well out of the taking off and landing areas.

18

These trials are said to be very promising, and operations of that type might give us some possibilities to keep the birds out of the routes of our aircrafts.

Here in Sweden we have been quite successful with our field-works, and measures, at the new Malmoe/Sturup airport, which was predicted to become a bird-dangerous airport, but where onlu a few trivial strikes are reported. In some of the memberstates, including Sweden, an extensive work is performed, in order to obtain systems for bird intensity fore-casts, which are one type of means, that we set our hopes on for the future.

BSCE has good relations to ICAO, and during the last year the relationship has become stronger than before, a fact which is of high importance for BSCE. The relationship is now officially described in the following terms:

"The BSCE acts in an advisory capacity to ICAO, working through the European Office of ICAO, on matters concerning the hazard to aviation caused by birds".

This is a significant claifying of the status of BSCE, as an international organization, which has been achieved through efforts of the European Office of ICAO and the Chairman of BSCE.

With these words, I would like to wish you all success in your important work here in Stockholm, during the Meeting, and also for the future. I hope, that we will gradually find better means, so that we can diminish the aircon-flicts between birds and man.

4. Report by the Chairman, BSCE, Mr V E Ferry, France.

BSCE/10
11 June 1975

Report by the Chairman BSCE 1975

The last meeting BSCE was held in Frankfurt 20 and 21 June 1974.

Last winter the report from the meeting was distributed by BSCE secretary with a delay due to strikes in postal services. The hospitality offered by the host nation Germany was outstanding and the participation of insurance companies has been noted as a new element that could encourage and guide our future action. I am still confident today seeing many new faces that incoming of fresh blood and brain is the best guarantee for good results.

On the whole the year's activity could be summarized by 81 incoming letters and 75 answering. (You can note that your chairman is a bit lazy on the paperwork side).

- A new group is to be established inside BSCE. The creation of the group was first mentioned within BSCE the 4th October when it was sent to the chairmen of the working groups and the editing committee for comments. As all answers were in favor, we have disseminated the proposal with chairman comments to all members. We had experienced a somewhat strong reaction from ICAO and we proceeded to some changes in the proposal. The report from the formation ad hoc group will give us more information.

- Contact with ICAO has been fruitful. We have reached an agreement as stated in a circular and printed on the paper dealing with ICAO circulated during 10th meeting.

- We are glad to welcome here representatives of Finland and Israel. According to a letter received a week ago Czechoslovakia will also be a member of BSCE for the next meeting. Also national representation has been enlarged.

- Professor Jacoby has been unable to attend our meeting but he assured me that they have not forgotten us.

21

- Our tentative to invite Lt.Col. Twijsel has not been successful. I deeply regret that for the 10th meeting we were unable to have with us all the previous chairmen to whom we owe our longevity and success. I hope that Colonel Schneider, who represents all of them will accept our gratitude for the work they have done and that you have kindly allowed me to check personally.

Finally, we have tried to give a permanent structure to BSCE. You certainly have noted that working papers this year were printed and numbered as was stated in WP 1 re printing terms of reference of working group and proposed terms of reference for the Committee. These changes have been necessary in order to ease our collaboration with ICAO. Please also see WP 6, Appendix B, giving a structure to our future work.

Up to this meeting the Organizing Committee which has done its job perfectly has distributed all papers in due time and built a fine timetable that I must respect and close now expressing our thanks to the Swedish committee for what they have done.

22

5. Reports by the chairmen of the working groups, BSCE

5.1 Aerodrome Bird Strike
Dr W Keil, W-Germany

5.2 Analysis
Mr J Thorpe, U.K.

5.3 Bird movement
Dr J Hild, W-Germany

5.4 Communications
Mr V E Ferry, France

5.5 Radar
Mr E W Honghton, U.K.

BIRD STRIKE COMMITTEE EUROPE

ACTIVITIES OF THE WORKING GROUP

1. Title: Aerodrome Bird Strike

2. Recommendations of the 9th meeting, Frankfurt, June 1974

2.1. It is recommended that a survey should be prepared and circulated of all aspects of bird hazards to aircraft at and around aerodromes (i.e. approximately within a radius of 7 nautical miles of the aerodrome boundary).

2.2. It is recommended that a list should be prepared of the technical specifications of all accoustic scaring devices, together with a summary of the results obtained during trials or in actual routine operation at aerodromes. All countries should provide the chairman with the current information.

2.3. It is recommended that all countries should provide details, operating procedure and results of all equipment (except accoustic equipment) which are in use, or available for purchase for bird scaring on aerodromes. A list of equipment should be circulated to all countries after the above details have been collected.

2.4. It is recommended that countries provide local or national regulations applying to garbage dumps and to controllable bird movements (e.g. racing pigeons).

2.5. It is also recommended that a survey be prepared and circulated on the use of landing lights, especially during daylight, in order to reduce bird strikes. If possible maintenance costs (e.g. extra consumption of light units), should be calculated using a similar period of time before that used as a reference

3. Recommendation of the 10th meeting Stockholm, June 1975.

The recommendations 2, 3, and 4 have been changed during the meeting of the Working Group on June 9th.

The new text is:

3.1. It is recommended that a list should be prepared of the technical specifications of all currently used bird dispersal devices for distribution by the Chairman of the Working Group.

Activities of the Working Group, cont'd

3.2. It is recommended that countries provide local and national regulations applying to garbage dumps and to controllable bird movements (e.g. racing pigeons).

3.3. New recommendation.

It is recommended that each country be requested to include on their bird strike reporting form the following new question:

"Were lights being used
Landing Yes ☐ No ☐
Strobe anti-collision Yes ☐ No ☐

4. Progress Report and future work

4.1. It showed during the last year that it was not possible to get answers on the base of the recommendations of the 9th meeting. For this reason 3 recommendations got a new text.

4.2. A proposal of a check list for the airport manager was prepared and will be sent to the members of the Working Group to give their comments. In December 1975 a meeting will be held at London to discuss the result of the comments by a sub group. On the next main meeting the check-list will be given to all member-nations and to ICAO.

It is the Chairman's opinion to held the meetings of the Working Group on such

Stockholm, 6 June 1975

Dr. Werner Keil
Chairman
Aerodrome Bird
Strike Working Group

25

BIRD STRIKE COMMITTEE EUROPE

ACTIVITIES OF WORKING GROUPS ESTABLISHED BY BSCE

1. Working Group - ANALYSIS

2. Recommendations of 9th Meeting, Frankfurt, June 1974

(i) It is recommended that a number of changes should be made to the Civil and Military Analysis forms so that they are easier to use, and are more informative.

(ii) It is recommended that the revised forms should be circulated to all countries as soon as possible for use at the earliest opportunity.

(iii) It is recommended that all countries should provide the name of the person who is responsible for the Civil Statistics, and for the Military Statistics.

(iv) It is recommended that all countries should produce the Analyses of their Civil and Military Strikes for use in future work.

3. Progress Report

3.1 A list of those responsible for Civil, and for Military Statistics was compiled during the Frankfurt meeting.

3.2 The appropriate changes agreed at the Working Group meeting in Frankfurt were incorporated, including the provision of comprehensive information about the damage resulting from strikes. The revised Military and Civil forms were circulated to the appropriate representatives during August 1974.

3.3 Information was received as shown in the attached Table.

3.4 The Reports on Bird Strikes to Civil Aircraft, and Bird Strikes to Military Aircraft, for the year 1973, were circulated to all members prior to the 10th Meeting in Stockholm.

26

4. Chairman's Report

4.1 Thanks are particularly due to those who have co-operated by sending their analyses correctly filled in on the BSCE Forms. The response on the Military side has been very good, however, on the Civil side it has not been as good as last year. It is hoped that more countries will be able to provide their 1974 Analyses.

4.2 Thanks are also due to Sq. Ldr. Salter for providing the Military Analysis Report. There were considerable difficulties as some countries were using the new forms, and some the old forms. Furthermore, for security reasons some countries were unable to provide either movement data or rate data. This has led to the lack of Conclusions in the Military Report. When everyone is using the new forms the problem will be partially resolved.

4.3 It is important to check carefully the addition, before sending the BSCE forms. Both Sq. Ldr. Salter and myself spent a lot of time examining our work for a mistake, that in fact had been made by someone else.

4.4 Please try to stick to the BSCE layout, some countries made some alterations that caused considerable difficulties when producing the Reports.

4.5 Make quite sure that your bird weight classification is consistent and correct, it does not help when in one Table, 2 birds of Cat C weight are shown, and in another 5. This is the reason for some of the inconsistencies in the Civil Report.

4.6 At the last meeting it was agreed that all countries would try to produce their Analyses on the BSCE forms, and there was no disagreement with this. It is understood that one or two countries do have particular difficulties, but from the attached table it can be seen that some countries have not provided any information on BSCE forms. These statistics will not prevent bird strikes, but the problem areas can be shown, so that measures can be applied most effectively.

4.7 In the Civil Report a special analysis has been made of strikes to engines. For this it was necessary for the ICAO data to be available. It was noticed that the exact engine type was often not stated. This omission should be rectified since the Boeing 707 and DC8 have a variety of engines.

J Thorpe
Chairman
Analysis Working Group

BIRD STRIKE DATA RECEIVED FROM BSCE MEMBERS

1973			1974		
MILITARY	**No**	**Rate**	**MILITARY**	**No**	**Rate**
Belgium	-	5.9	Belgium	-	4.20
Canadian Forces Europe	23	11.4			
Denmark	52	-	Denmark	46	2.95
French Air Force	119	-			
French Navy	22	-			
Netherlands	94	6.4			
Portugal	0	0			
Spain	10	-	Spain	11	-
Sweden	184	5.9			
United Kingdom	511	3.1	United Kingdom	459	4.06
USAFE	65	-			
CIVIL			**CIVIL**		
Denmark	42	1.90			
France	54	1.10	France		
Germany*	286	8.25			
Netherlands*	154	10.80			
Sweden	75	1.75			
Switzerland	55	3.1			
United Kingdom	318	3.20	United Kingdom	355	-

* BSCE Analysis Forms NOT used

BSCE/10
12 June 1975

Activities of the Working Group

1. Title: Bird movement.

2. Terms of Reference: Study of bird concentrations and movements and drawing up of special maps for the information of aircrews and aviation services.

3. Progress report:

   a) The existing collection of bird concentration and bird movement maps, published in 1973/1974, is revised regarding the newest knowledge about bird concentrations and bird movements.

   b) Some countries published specified maps about bird concentration in the surrounding of aerodromes and air-fields. At the moment Germany is drawing up such maps for NATO airfields in Germany.

   c) ICAO accepted maps for publication in AIP by each country. Denmark, Belgium, Germany, France, UK published maps in the AIP; Switzerland prepares publication.

   d) According to recommendations of the 9th meeting Belgium and Germany had discussions about development of one European Bird Hazard Map which is based upon a scientific background, but which must be simplified for operational purposes. This map differs - on the basis of ecological status - 3 types of danger/ risk: heavy, moderate, light, depending on bird size and quantity (biomass) per square kilometer. Moreover, this map should show bird conservation areas of more than 250 ha and smaller areas which seem or are (proved by bird strikes) a high risk. Belgium, France, Denmark, Sweden, and Germany published a first draft.

4. Future program

   a) Revision of existing maps

   b) Drawing up of more specified airport surrounding maps

   c) Drawing up of bird hazard maps on the basis of standardized indications.

5. Recommendations

   - Existing maps should be published in the AIP of each country -

   - Before printing new maps for AIP please send it to the other members of the working group for comments. (3 x)

   - Revised maps should be sent to the Chairman as soon as possible, regarding standardization and neighbour countries. Deadline 31 December 1975.

   - Representatives are requested to send quantitative indications about birds in large areas for calculating the biomass (according to Working Group letter from December 9th, 1974) as soon as possible to the Chairman. Possibly classification of risk (numbers of birds) should be changed after getting further informations.

Countries which are not able to give these informations at the moment should try to deliver specified indications within the next year.

Representatives appointed by the working group are requested to continue their work with the aim to get a usable map draft for consideration before the next working group meeting.

BIRD STRIKE COMMITTEE EUROPE

ACTIVITIES OF WORKING GROUPS ESTABLISHED BY BSCE

1. Working Group: COMMUNICATIONS

2. Recommendations of 9th meeting, Frankfurt, June 1974.

   (1) That the system already in use (RSFTA/AFTN, Bird warning messages and Bird Migratory movements forecasts) be used internationally.

   (2) that two periods of one week in length be selected to test the whole system one in Autumn 74, and one in Spring 75. All weak points which could appear will be eliminated whenever possible.

   (3) that a study group be formed inside the W.G. to develope a phraseology procedure covering the Bird problem by R/T procedure: i.e. pilot to controller and vice versa.

   (4) that pending results from the study group, the working group shall be suspended for a time, but could be reformed, if necessary.

3. Progress report

   3.1. The survey of birdtam (14 to 20 October 1974) has been circulated by BSCE under WP.3 on 14 January 1975. Report from Germany arrived too late, due to a postal strike, to be included into the summary.

   The paper has been briefly discussed during W.G. session connected with 10th meeting and its shortcomings pointed out. Members pointed out the delays in transmission sometimes exceeding largely the validity of message. However,it was agreed that they were still allowing a checking of the available information.

The contents of message was again discussed, as at least one member advocate use of plain language.

It was pointed out that a new rule from ICAO in force on October 9th 1975 will off-set present system and notam code will be used.

It was agreed that messages initiated from Air Forces will be incorporated somewhere in the beginning of plain text the five letters of notam code identifying bird hazards.

Chairman was requested to approach various organizations to eliminate weak points shown by the summary.

3.2. Informations necessary for the record period summary were not completely available for the time of meeting. It was agreed that the paper be circulated later.

3.3. Chairman has been asked to evaluate the use of MOTNE system when available, its present overloading not permitting transmission of bird information. Appropriate action during next MOTNE panel is planned.

3.4. A new period of six days during September will be selected and details published by a BSCE circular.

3.5. Phraseology, amended by letter from Sq.Ldr. SALTER on March 11, 1975 has been circulated under BSCE WP/2. Comments made have shown clearly that the phraseology is agreed. BSCE will be requested to send it to each National Committee for immediate use and one, or more, State, will be charged to present the procedure to ICAO for comments and, if possible, adoption.

4. Chairman's report

4.1. From the brief discussion it appears that two actions

32

were necessary. On the civil side to obtain a better follow up on messages dissemination, both with regards to speed in transmission and addresses because some messages are lost en route. On the Air Force side to adapt the system already in use to incorporate, starting in October 75, the new Notam group allocated to bird hazards.

4.2. Some concern has been expressed about the use of phraseology covering bird hazards, and one member has enhanced the necessity of studying recommended avoiding action, which is outside the scope of this W.G. - However, informations could be made available about some testing made in different States.

4.3. It has been suggested to proceed with routine testing on messages, and the need of evaluation centers has been stressed again.

4.4. Thanks are due to Sq.Ldr. Salter for the work done inside this group.

RADAR WORKING GROUP, BSCE - Chairman's Report

1. Terms of Reference: The Radar Working Group of BSCE deals primarily with matters associated with the use of radar in surveillance, identification and assessment of bird movements.

   The Group is composed of engineering, operational, and research scientists and operational flight control officers and flight safety officers currently using radar on bird strike and allied problems.

   The work of the Group embraces the evaluation of the radar properties of birds, of specific radar equipments and techniques, of improvements in design and data handling, and also "best" ways of operating radars.

   The Group was formed to advise BSCE in radar matters and to enable countries to exchange information in radar techniques and the operational use of radar.

2. Exchange of Information: Nederland discussed the reforming of their radar observation group with Switzerland, Canada, and UK. Canada discussed methods of identifying birds.

3. Lectures: A number of short lectures of current interest were given to provoke discussion and exchange views. Lt. Clausen (Royal Danish Air Force) gave us a talk on "PPI bird echo intensity versus echo counting - present status". In this lecture he brought us up to date with the Danish work on comparing the results obtained by photographing the plan position indicator and by electronically counting echoes contained in selected areas. Lt. Soetens (Royal Belgian Air Force) then gave us a short resumé of his paper "Experimental Bird counting with a real-time computer", which he will give in full at the Main Meeting.

   Both the Danish and Belgian experiments are two different methods of finding a quantitative value for the intensity of bird movements observed by radars without the longer and more difficult task of photographing the PPI and counting echoes. Talking in terms of computers - the Danish method is largely a hardware solution involving a modest addition of electronic equipment to the radar, while the Belgian method is a soft-ware solution not requiring additions of equipment to their radar. The Danish solution makes use of raw radar data, while the Belgian solution makes use of primary plots of processed video data. We hope these methods will be widely considered and their advantages and disadvantages brought out in the future.

   From time to time it has been suggested that the Group should consider other forms of electro-magnetic wawe sensor than radar for bird movement surveillance. Mr. Houghton (UK) described a medium-wavelength infrared thermal-imaging sensor

capable of night and day surveillance of airfields in haze conditions, which would preclude the use of visible-light sensors.

4. Tasks: A task which the Group has been considering for some time has been to relate the 8-point PPI echo intensity scale obtained on radar to a definite bird strike risk. At a previous meeting the Radar Working Group recommended that the problem be divided into three parts:

(1) Relation between obtained radar data and the bird movement data

(2) Relation between bird movement data and the bird strike risk

(3) Relation between obtained radar data and bird strike risk

Part (1) and part (2) of the resolution involved some kind of mathematical modelling using data obtained by radar and birdstrike rates obtained from the airfield. The principle of mathematical modelling has now become widely accepted in physical, biological and social sciences. Modelling is one of the only ways of pinning specifications and relating quantitative results to a complete subject. Models are not reality but they can be developed with confidence provided reality is not distorted to fit the model. The Group is convinced that the first part of the solution can be done by using known realistic models. The second part of the resolution raises many problems and so that previously the Group had suggested the subject should be investigated by a new group. However, after a long discussion at this meeting the Group having now decided to attempt to make a model relating bird movement data and the probability of bird strike. Already Dr. Hunt (National Research Council Canada) and Lt. Meyer (USAF) have developed methods of relating radar bird observations with bird strike probability.

Consequently, the Group recommends that a paper relating obtained radar data and bird strike probability should be prepared and sent to appropriate members of each country in BSCE for consideration and comments. The paper will be prepared by Dr. F. Hunt (National Research Council, Canada).

6. Papers presented at the meeting:

WP No	Division according to WP/6 app. A	Title
4	I, 1b	A radar study of wild duck E W Houghton, U.K.
5 A	II, 1	Bird strikes during 1973 to European registered civil aircraft J Thorpe, U.K.
5 B	II, 1	Military aircraft bird strike analysis 1973 A Salter, U.K. (presented by H Lake, U.K.)
8	III, 3	Dispersal of gulls from the airport environment J F Stout, U.S.
9	III, 4	Synopsis of the organization and activity of the BSC Belgium in 1974-1975 J F Boomans, Belgium
10	I, 2a)	Further lapwing investigations on Beauvechain airport J Heirman, Belgium
11	I, 2b)	A Belgian bird strike risk map based on numbers of birds to the unit of area J Heirman, Belgium
12	I, 1b) & 2b)	Experimental birdcounting with a real-time computer G Soetens, Belgium
13	I, 2a)	The blackheaded gulls are assigned their quarters on airfield M Laty, France
15	I, 1	Prediction of the spring migration of snowgeese across the terminal control area of Winnipeg international airport H Blokpoel, Canada
19	II, 1 & 2 III, 1b)	Global statistical approach to the birdstrike C Lavau, France
20	III, 1a)	Studies of birdreactions, caused when exposed to laser-light L Ståhl & S Johansson, Sweden
22	III, 4	Bird strike prevention success and malaise in the RNLAF L S Buurma, Netherlands
23	I, 2b)	European Bird Hazard Map A Holm Joensen, Denmark

36

WP No	Division according to WP/6 app. A	Title
24	I, 2a) & III, 3	Bird strike problems at Ben-Gurion airport, Lod-Israel S Suaretz, Israel
27	I, 1 & III, 5a)	Spring migration of cranes over southern Scandinavia T Alerstam, Sweden
28	II, 1 & III, 5a)	Bird strikes in Sweden 1967-1974 J Karlsson, Sweden
29	I, 1 & 2b) II, 1	The use of waterfowl count data in bird-strikes work in Denmark A Holm-Joensen, Denmark
33	I, 1 & III, 5	Automatic warning of hazardous bird conditions F R Hunt, Canada
	II, 2	Bird strike problem from air technical point of wiew A Roed, Sweden
	I, 1 & III, 5	How many birds are there? S Ulfstrand, Sweden
	III, 4 & 5	Current activity concerning the U.S. Bird/Plane strike problem J L Seubert, U.S.
	III, 4	Bird Hazardz to Aircraft (Contents) H Blokpoel

AD F 616 194

BSCE/10-WP/4

(paper given at the 10th Bird Strike Committee Europe Conference, Stockholm 1975)

A RADAR STUDY OF WILD DUCK

E W Houghton F Blackwell M Ogilvie* and T A Wilmot

The author * is at the Wildfowl Trust, Slimbridge, Glos and the other authors are at the Royal Radar Establishment, Malvern, Worcs in the United Kingdom.

SUMMARY

This is a study of the mallard. Flight and echo data were obtained by means of a high-resolution auto-following pulse radar from wild birds released from the ground. A map of the operational zone with X-Y tracks and height and velocity diagrams are given for the best flights. Static radar echoing areas are compared with dynamic echoing areas obtained from the results of a flight. Bird activity modulation waveforms and spectral diagrams have been analysed for some of the longer flights. Released mallard flight and echo results are compared with results taken on "wild duck" tracked at night during the peak of the autumn migration. Correlation methods are introduced for the first time in analysing bird echo waveforms.

CONTENTS

1 INTRODUCTION

When radars are considered as sensors in the bird strike problem they can be employed to give warning of birds intruding controlled airspace, or for examining the behaviour of species thought to represent a threat. In the latter case it may be necessary to identify species by radar means alone as it may not be possible to use radar-visual correlation and confirmation.

Some species such as the swift (Apus apus), the starling (Sturnus vulgaris), and the honey buzzard (Pernis apivoris) have been examined simultaneously by a surveillance radar recording the large scale movement of a flock and a high-resolution radar tracking one or two birds in the same flock. Such studies which were subjected to visual checks indicated that species can be identified using radar means alone once their characteristics are known. No comprehensive catalogues of radar flight and echo characteristics of bird species corresponding to the field guides on visual recognition, habits, and habitats have been compiled up to the present, although a radar field guide on magnetic tape which would concentrate on flight and echo characteristics is a practical proposition. Without such a guide identification by radar means alone is bound to be extremely restricted. The great need is therefore for more detailed radar studies of particular species which will provide results for a guide.

UK statistics indicate that whereas gulls head the list of struck species, duck lie near the bottom; but duck, because of their mass nearly always cause serious damage. The mallard (Anas platyrhynchos) is one of the commonest and widespread of the wild duck in Europe. Both from the bird strike point of view and as representative of the duck species, the mallard is an excellent subject for a detailed radar study.

The best way of collecting flight and echo information on wild birds is on an opportunity basis as they fly past a radar on local or migratory flights. Birds on such flights going about their business unaware of outside surveillance generate characteristic data and are usually flying high enough to avoid the problems of low elevation angle tracking. However, the amount of time that can be allocated for the use of a high-resolution instrumentation radar for bird studies generally precludes working on an opportunity basis, except on nocturnal movements at peaks of the seasonal migrations when more targets can be acquired than can be recorded.

Another way of collecting bird data is to release captured wild birds from the ground, a tower, a balloon, a helicopter, or an aircraft. The radar is put-on to the known bird by optical means and after release it is followed automatically by the radar. The method is not ideal because a captured wild bird has usually been held for some time and so it may not generate typical information when released. Aircraft releases are also complicated by the buffeting the bird receives after being dropped. Birds, wherever they are released, tend to seek lower flight levels and often soon land. Wildfowl Trust experience with wild duck indicated that they usually make for the nearest water to alight on after release. The radar operation presents problems too, because although the radar beam is put-on to the bird by binoculars, the radar (if on auto-track) will choose the biggest target area which may be the ground, tower, balloon gear, helicopter or aircraft immediately after the bird has been released.

In spite of these difficulties very good data can be obtained from released wild birds as will be shown in this paper. Eighty mallard of both sexes were captured in Gloucestershire and released from the ground near to a C-band (5.5 cm wavelength) high-resolution auto-tracking radar in Wales. About 30% of the birds were used in "dry" runs to get the operating drill right and also in an attempt to find a release point which would encourage the birds to fly high and as far as possible. The birds were released in two trials which took place in late February and early March, and most of the "dry" runs took place in the February trial when the putting-on binoculars had a limited azimuth arc of 120 degrees.

Good echo waveforms and spectra were obtained from successful runs, but,as the mallard flights were very erratic as compared with duck on migration, waveforms and spectra show the effect of short term aspect fluctuations. Spot estimates of the dynamic echoing area were calculated from measurements taken on a run where the bird presented a broadside aspect and the results are compared with static measurements.

The paper is illustrated with a map of the operational zone superimposed with the best mallard tracks, and also the corresponding height-time and velocity-time diagrams. BAM waveforms and spectral diagrams have been analysed for some of the longer runs.

Released mallard flight and echo results are compared with results taken on birds tracked at night during the peak of an autumn migration. The birds on nocturnal flight could not be identified by visual means but they have generated radar characteristics similar to those obtained from mallard.

Correlation methods are introduced for the first time in assessing bird echo waveforms. They open up the field of identification and the search for the weak periodic signal hidden in random fluctuations.

2 THE MALLARD

The bird selected for the study was the mallard (Anas platyrhynchos). This species is the commonest and most widespread wildfowl in Europe. It breeds in every European country, though more densely in the north of the continent than in the south. It winters wherever there is open water, vacating only the more northern and eastern regions. While some populations are sedentary, others are migrants, travelling up to 2500 km in spring and autumn. It occurs on a very wide variety of wetland habitat from the smallest farm pond to large reservoirs, estuaries and marshes. The estimated wintering population for Europe and North Africa is 2½ million[3]. Flock size varies from a few tens to several thousands.

Although mallard fly mainly at night when on migration, they move around freely during the day at all other times of the year. Once established at a wintering area they tend to confine their movements to within a comparatively small radius[1], often establishing a pattern of dawn and dusk flights between their roosting place, on open water, and their feeding site, which may be on wetland or farmland. Mallard are fast and powerful flyers, and weigh on average 900-1200 gm.

9/

Further major advantages in studying mallard are that reasonable numbers can be readily trapped from the wild and, being a robust species, the birds can stand several hours in a carrying basket. This was necessary between the catching site in Gloucestershire and the release point in Wales. Matthews[2] has used large numbers of wild caught mallard for studying orientation and has shown that short term captivity, and confinement for a few hours in a carrying basket, has no adverse effect on the flying ability of the birds on release. Matthews' work has also demonstrated that within a matter of seconds of release mallard would gain height and be flying strongly and steadily away from the release point in a more or less predictable direction. These were both important requirements enabling the radar to track each bird and obtain worthwhile data.

3 EXPERIMENTAL WORK

3.1 Radar, Recording and Computing Facilities

The C-band (5.5 cm wavelength) instrumentation pulse radar used for these experiments has a range precision of 8 feet and an angular precision of 0.15 mils (0.0084 degrees). The diameter of the radar resolution cell at a range of 10,000 ft is approximately 140 ft.

The radar can track automatically a small target and generate 3 dimension positional data in polar coordinates, and an amplitude-time record of the echo signal. Flight and radar echo signal data together with time (GMT or ZT) code and voice description of each radar target engagement were recorded on a multi-track magnetic tape for subsequent analysis.

Target trajectory data was fed into the RAE data and computing centre on site, where polar coordinates were transformed into cartesian coordinates and the velocity and acceleration information was obtained by means of mathematical curve fitting procedures.

Wind velocities at appropriate altitudes and times were obtained during the trials by using the radar to track balloon-borne reflectors.

3.2 Visual Acquisition and Radar Putting-on Operations

Because of the small resolution cell and lack of aerial volumetric search facilities it was necessary for the high-resolution radar to be "put-on" to the target. Each mallard was observed against the centre cross-wire of special binoculars before being released. Angular positional data fed from these binoculars was used to put the radar on to the bird and follow it after release. The problem of transferring from visual to radar acquisition was not a simple matter, because although the bird was kept within the radar beam while it was in the field of view of the binoculars the visual operator could not provide satisfactory range information. When the duck was released close to the radar the radar operator had no range information until the bird had flown far enough to appear at the start of the range display scale. When the release point is on the ground the bird echo must be detected and tracked through a barrage of fixed echoes from ground objects. The radar operator depends upon getting glimpses of the wanted echo in nulls in the ground clutter on his range display from time to time. He must correctly estimate

the manual tracking rate necessary to keep up with the movement of the bird so that the range gate always coincides with the bird echo when it pops up out of the ground clutter. While the radar operator is coping with this task the visual operator on the binoculars must keep the bird within the cross-wires and hence the radar beam on target. Only when the bird has gained height and decided on its course does the ground clutter level fall sufficiently to permit the radar to be switched to auto-follow. Mallards are fast birds in flight and in these trials preferred low level flights.

The selection of a release site presented many problems. Ideally, it should be in perfect view of the visual operator but be beyond the minimum range of the radar. It should be in a region of minimum ground clutter and positioned so that the bird is induced to gain height. There must be reliable two-way communication between the ornithologist releasing the birds, the visual and radar operators, and the recordists. In these trials we had a trials manager who was responsible for starting and stopping a run and coordinating all operations. Three sites were tried and the two fulfilling most of the requirements proved unsatisfactory, because we failed to estimate reliable two-way communications and the visual operator had great difficulty in following the bird against the dark background in the poor light of late afternoon.

Finally the birds were released close to radar where the visual operator and communications problems were reduced but the radar operator's task was very difficult.

The acquisition and tracking operation required great skill, a first class operating team and a carefully worked out and tested drill. A number of birds had to be released to get the drill right and those "dry" runs did not produce useful data.

4 RESULTS

Flight and echo characteristics are given only for runs where it was possible for the radar to auto-follow well enough to produce satisfactory velocity data. Although the radar is capable of making over 1000 measurements of target position a second it requires about 3 seconds of data to enable the three components of velocity to be computed satisfactorily.

The first trial, X145501, on 28-2-69 generated good data from nine birds out of forty. Run G1 gave the longest record of 100 seconds and run K1 the shortest record of 3 seconds. The second trail, X145503, on 12-3-69 produced good data from twenty-one birds out of forty. Run S2 gave the longest record of 197 seconds and run T2 the shortest record of 3 seconds. The flight and echo characteristics of two birds observed during Autumn nocturnal migration and possessing the radar characteristics of ducks are given for comparison purposes.

4.1 Flight Characteristics

A map of the operational area is given in the plan position diagram of Fig 1. The map can be read in terms of Eastings-Northings with the origin in the

left-hand bottom corner or in terms of X-Y coordinates with the radar origin. Some of the chief land marks: the cliff line, a stream (Allt-y-Gwryddon), a farm (Pennar-Uchaf), and height contours are shown on the map. Height-time of flight and ground velocity-time of flight diagrams are given in Fig 2, 3, 4 and 5. Height is plotted in terms of height above sea level. The radar is approximately 500 ft above sea level, NEWLYN.

A selection of the runs, which produced useful radar data are shown on the map. None of the birds were transferred to suto-follow immediately after release, consequently many of the tracks do not start until the birds were near to the end of their flights. Runs D1, E1, A2, D2, E2, J2, O2, P2, R2 and U2 were terminated when the birds diving* towards the sea were about a beamwidth off the cliff edge. Runs L1, L2 and Q2 were abandoned when the bird echoes were lost in ground clutter and at least one of these birds was seen to have landed in a field.

A few examples of these mallard runs will now be given in greater detail:

Example 1 Run E2, the bird was followed with difficulty through ground clutter and then was lost in range by the radar operator just as the duck commenced to gain height. The visual operator followed it throughout this period, but it was not found again in range and put on to auto-follow until it was diving towards the sea from 520 ft, Fig 3. Satisfactory values of velocity in the dive were obtained and these are given in Table 1, a tabulated summary of the speed characteristics of the released mallards.

Example 2 P2 was an interesting run, the bird was transferred to auto-follow just before it left the cliff line and flew northwards over the sea. The mallard climbed in altitude and then levelled off for a moment at about 400 ft, Fig 4. The ground speed was about 81 ft/sec (48 kts) at this point. The duck then went into a dive towards the sea, turned NNW, and the ground speed oscillated and increased. The bird then changed direction starboard, headed into the wind (at about 18 seconds), and the ground speed dropped, Fig 4. Then the duck commenced to head to port, out of the wind (at 25 seconds), and its speed increased. At flight time 30 seconds, the duck was flying westwards into a tail wind and the ground speed was approximately 90 ft/sec. The bird was flying at a speed of about 70 ft/sec (41 kts) at this point as the tail wind was about 20 ft/sec. By this time the bird had descended from 400 to 250 ft. In the region of 54 to 56 seconds the bird circled round into the wind again and the ground speed dropped to about 30 ft/sec, but the bird was flying at an air speed of about 50 ft/sec (30 kts). The mallard turned out of the wind and its speed started to rise at flight time 57 seconds. The duck was lost by the radar after about 90 seconds.

Example 3 Run S2 ended in a doubtful situation where the mallard had commenced to dive towards the sea and then apparently made a full loop, climbed and flew back inland. Examination of the relevant portion of the echo record showed that the 6.5 Hz mallard wingbeat "signature" was absent after the target reached the lowest point on the height-time diagram, Fig 5, and was replaced by the 3 Hz wingbeat "signature" of a herring gull (Larus argentatus). Apparently just at the crucial moment before the duck was lost below the cliff top a gull flying up from below the cliff same into the radar beam. The radar still on auto-follow was thus taken over by the strong gull echo and consequently followed the gull inland. The portion of the

(FOOTNOTE: *"dive" in this paper means a controlled relatively steep descent)

height-time diagram after 100 sec, when the gull replaced the mallard has been omitted.

Unidentified "duck" flight characteristics

Now we shall describe the characteristics of two birds obtained late at night on 25-10-68 using the same radar. These were just two of many such records obtained during studies of Spring and Autumn migrations. From our limited results (we were looking at 2 minute runs only at that time) we cannot say definitely whether these particular birds were migrating or not. However their altitudes, and uniformity of radar characteristics indicated something more than local "short hop" flights.

Run 006/68 This bird was picked up at 21.51 hrs at a ground range of 14 nautical miles (X negative 80,000 ft, Y negative 26,000 ft) and beyond the limits of the map, Fig 1. Altitude was 4,620 ft for the duration of the record of 90 seconds. Measured ground speed was 28 ft/sec and the wind velocity at altitude, 26 ft/sec, SSW. As the radar track was relatively straight and moving due South, the estimated air speed of the bird was about 51 ft/sec (30 kts). These interesting characteristics indicate that the bird was heading into a relatively strong wind and maintaining a fairly uniform velocity and altitude. It is a pity that we had no "on-line" data print out at the time, because it would have been interesting to see how long this bird carried on fighting the wind.

Run 018/68 This bird was picked up at 21.85 hrs at a ground range of 18 nautical miles as shown on the map, Fig 6. The map origin in terms of Eastings-Northings or X-Y coordinates is at the radar. This bird was flying at a relatively constant height of 5235 ft and a ground speed of 41 ft/sec. It was heading WSW into a 27 ft/sec SSW wind at an air speed of 54 ft/sec (32 kts).

4.2 Radar Echoing Characteristics

Broadly speaking, the "average" echoing areas of many species vary relatively slowly with time as their aspect changes when flying past a radar in steady flight. Although at any aspect, over a small solid angle, there may be a peak or valley in the overall echoing area, the "average" echoing area is usually larger broadside than at head or tail aspects. The instantaneous value of echoing area also varies periodically with time about the "average" value at the wing-flapping rate as body shape and wing position change rhythmically in steady flight.

These changes of echoing area generate an echo signal with an "average" component which changes relatively slowly, and a modulated component which changes fairly rapidly and repetitively about the "average" value at the wing-flapping rate. The modulation is bird activity modulation (BAM) which is a characteristic feature of the echo signal from a bird. Such signals whose "average" level and modulation index remain fairly constant for periods longer than the radar scanning or processing time are generated by many species, such as duck on migration. Generally, relatively constant echo signals are more likely when a bird is showing its broadside aspect than head or tail aspects. As far as this paper is concerned, a "constant" echo signal

is one that appears so to the radar processing most of the time the bird is being tracked but which may fluctuate violently from time to time.

4.2.1 Static and Dynamic Echoing Areas

Because the echoing areas of birds are very complex it is necessary to measure them by experimental methods. Static measurements are taken at a large number of fixed aspects on a dead bird with a miniature radar indoors. The radar echoing area (REA) diagrams made under these conditions can be accurate and complete with a fine structure but they give no indication of echoing area variations produced by the bird in flight. They enable a good estimate to be made of the average REA over aspect of 40 degrees or more. Dynamic measurements of the bird in flight are required, to back up any predictions based on static measurements. But due to the problem involved getting the bird to fly in a specific way where it is wanted,and of establishing aspect in three planes, dynamic echoing area measurements can usually only be made at a very limited number of aspects and they are less accurate.

Static Radar Echoing Areas of Mallard

Experimental REA diagrams of a number of wild birds have been made by EMI Electronics on a contract directed by RRE. Dead birds were "set" with open or closed wings using prolonged rigor-mortis by the Pest Infestation Control Laboratory, MAFF. A fuller description of the measuring and calibration techniques, results and diagrams are given in an unclassified NATO publication (4).

REA cartesian diagrams of mallard drakes measured with open and closed wings are shown in Fig 7. The miniature radar was operated as a monostatic radar (bistatic angle 6½ degrees) at a radio frequency of 3.85 GHz. Aerial elevation was 7 degrees and the aerial electric field polarisations were vertical for the bird with open wings and horizontal for the birds with closed wings. Birds were photographed at every azimuth position aspect at which the REA was measured in order to check the "set" position was retained. The vertical scale of the REA diagrams is plotted in terms of radar echoing area (sq cm) and the horizontal scale in terms of azimuth aspect angle (degrees). Only half of the diagram from 0-270-180 degrees is shown as the other half is practically a mirror image (Note: no body can be "set" exactly symmetrical). Although the fine structure in the two diagrams differ as a result of differences in body shape, wing position and aerial polarisation, they share certain common features, such as, the highest values of REA occur about the broadside aspect at 090 and 270 degrees and the lowest values of REA about the head and tail aspects. From measurements on two drake and two duck mallard taken under similar conditions, the average REA ($\pm$ 20 degrees) about broadside aspect range from 87 sq cm (vertical polarisation) for an 860 gm duck with closed wings to 122 sq cm (horizontal polarisation) for a 1310 gm drake with closed wings. A good approximation for the REA averaged over the whole 360 degrees in azimuth aspect is 40 sq cm for either sex irrespective of wing position or polarisation. The valleys and peaks in the fine structure REA diagrams range widely from as low as 1 to as high as 400 sq cm. The REA's of head and tail aspects show a great range of variation from 1-30 sq cm head-on ($\pm$ 20 degrees) to 1-29 sq cm for tail-on ($\pm$ 20 degrees).

Dynamic Radar Echoing Areas of Mallard

A repeatable REA of a bird in flight can be obtained when the bird passes through the broadside aspect and it is flying steadily in level flight. It is usually quite easy to find the broadside aspect on the echo signal versus time record without reference to map track and height versus time graphs (See Chapter 3.2.2 and echo record Fig 4 in the paper (5)), although it is always advisable to check aspect using the data mentioned in chapter 4.1 and the appropriate wind velocity. When the bird is flying erratically as in this case it is essential to check the aspect using all available information.

The method employed to obtain dynamic REA's in birds has been described in the paper just mentioned (5). The output range of the radar receiver and echo signal recorder is calibrated at decibel intervals by means of an aerial and signal generator fitted on a tower. A reference sphere of known REA carried by a balloon is tracked by the radar and the echo amplitude from the sphere is recorded against radar range. Under similar radar conditions, a bird is tracked and its echo signal amplitude recorded. The echo signal amplitude and radar range R_1 corresponding to the bird passing through the broadside aspect are found. An identical echo signal amplitude is now found on the reference sphere echo signal record and the corresponding radar range R_2 noted. The REA of the bird at the broadside aspect is given by:

$$\text{Broadside REA of Bird} = (R_1/R_2)^4 \times \text{REA of Reference Sphere}$$

A number of mallard runs were examined but only in one of them did the mallard fly right through the broadside aspect. This run P2 did not provide steady flight conditions. The bird passed through the broadside aspect in run P2 after about 60 seconds of flight at a radar range of approximately 8000 ft. At this range the mallard's echo signal value was identical with the reference sphere's echo signal value when the sphere was at a radar range of 11,000 ft. The echoing area of the P2 mallard is therefore:

$$\text{Broadside REA of mallard} = (8000/11000)^4 \times 0.02 = \underline{56 \text{ sq cm}}$$

where the REA of the reference sphere is 0.02 sq metres at the radar operating wavelength of 5.5 cm. Vertical aerial polarisation was used. Thus we find that the dynamic broadside REA of the mallard is less than the static broadside (± 20 degrees) REA but larger than the static REA averaged over 360 degrees in azimuth. The reason for differences in broadside REA's is mainly due to the different characteristics of the static and dynamic echoing areas and to a lesser degree to measuring problems.

4.2.2 Bird Activity Modulation Waveforms, Spectra and Correlation

The instantaneous amplitude of the echo signal varies in a quasi-periodic manner with time as the bird flaps its wings. The wingbeat "signature" is the most distinctive radar characteristic of a flying animal, but a bird may move its head, its feet or may pause, soar or glide in flight, and so RRE has termed all rapid echo modulations generated by a bird as bird activity modulation (BAM). There is a great deal of film and radar echo evidence that shows both Old and New World species maintain a definite wing beat frequency, which is often within 10 to 20%, when cruising under uniform

8

flight conditions. Wingbeat "signature" alone does not of course enable hundreds of different species to be identified individually by radar, but an estimate of physical dimension (vital in the bird strike problem) is possible (6). There is little difficulty at all in sorting out finches from duck, duck from geese and geese from gulls if the radar can be used to resolve one or two birds at a time. Further classification of species is also possible using a logic based upon geography, population, time of day and season. While further analysis of the content of long BAM records for harmonic content and wing pause, flapping and glide duration and occurrence extends the possibility of better identification. In the latter cases, flight conditions and echo linearity must be known.

BAM Waveforms and Spectra of Released Mallard

The BAM waveform and chief frequency components of the mallard, run C2, released on 21-3-69 is shown in Fig 8A. Signal amplitude along the vertical axis and time of flight along the horizontal axis are plotted for a 6 second duration of the radar echo signal record. The top waveform is the BAM waveform after passing unaffected through a 0-40 Hz lowpass filter. The bottom waveform is the same waveform after all frequency components have been removed except the fundamental component centred on 6.5 Hz and components lying close to it within a band 6-7 Hz. The waveform above the fundamental is that of the second harmonic components of the complex BAM waveform lying between 12-14 Hz. Above the second harmonic waveform is the third harmonic components waveform, which lie between 18-21 Hz. Filtering is a convenient method of simplifying a complex waveform and it is explained briefly in Appendix A. Unfortunately at the time it was not possible to make the bandwidths of the fundamental and harmonic bandpass filters large enough or of equal bandwidth and consequently it is not possible to compare envelope fluctuations of the complex and harmonic waveforms in detail. Looking at the complex BAM waveform for the whole 6 seconds we might guess the signal had some periodic components but it would be difficult to resolve them without analysis. A consideration of the harmonic waveforms show their amplitudes rise and fall in a complicated way and that maxima and minima in one harmonic waveform does not always follow its relative.

A better way of investigating the frequency content of a complex BAM waveform is to plot its spectrum by means of an electronic spectrum analyzer. The frequency spectrum of a mallard, run C2, is shown in Fig 8B. The echo signal is plotted along the vertical axis and frequency along the horizontal axis. Four spectra of the BAM waveform record taken at 5 second intervals are plotted one above the other on the left-hand diagram, Fig 8B. A spectrum averaged over the whole duration of the echo record is shown in the right-hand diagram. We see from the right-hand diagram that the analyzer has resolved the whole complex BAM record into fundamental and second and third harmonic components, and the fundamental has the greatest amplitude. A look at the left-hand side diagram confirms the results of filtering that the fundamental and harmonics components are not always present together as shown for the average for the whole record, but any of them may be at a minimum. However in spite of the complexity of the BAM waveform and the occasional loss of the fundamental it is possible to measure the fundamental as 6.5 Hz, which is the average wing beat frequency of mallard measured with a calibrated cine-camera when cruising in level flight.

The BAM waveforms and spectra of mallard, run L1, released on 28-2-69 are shown in Fig 9A and 9B. The dominant waveform and spectral response in Fig 9A and Fig 9B is the second harmonic. The fundamental frequency component is 6.9 Hz.

The BAM waveforms and spectra of mallard, run P2, released on 21-3-69 are shown in Fig 10A and 10B. The dominant waveform and spectral response in Fig 10A and Fig 10B is the second harmonic. The fundamental frequency component is 6.7 Hz.

The BAM waveforms and spectra of mallard, run S2, released on 21-3-69 are shown in Fig 11A and 11B. The dominant waveform and spectral response in Fig 11A and Fig 11B is the fundamental. The fundamental frequency component is 6.5 Hz.

The BAM waveforms and spectra of "migrating duck", run 006/1 and 018/1 obtained at night in October 1968 are shown in Fig 12A, 12B, 13A and 13B. although the BAM waveforms are complex they are continuous and clearly periodic. The dominant waveforms and spectral responses in both Fig 12A, 12B, 13A and 13B are the fundamentals. The fundamental frequencies are 6.4 Hz for run 006 and 6.5 Hz for run 018. Note that fundamental components are present throughout the duration of the records, and the spectral responses are much narrower in width than those produced by released mallard.

Correlation

Radar identification depends upon a process of searching for and finding similarities between reference target flight and echo data, and unknown target radar data. Already we now compare the spectra of BAM waveforms quantitatively, but a method more suitable for automatic processing is to compute the degree of similarity between waveforms by means of correlation. Correlation can also be used for searching for a weak periodic BAM waveform hidden in random fluctuations or mutilated by erratic fluctuations in aspect. Before we attempt to correlate a reference and an unknown waveform we need to know if the unknown is a periodic signal or not. We can find this out by auto-correlation. This is a method of correlating a waveform with a time-shifted copy of itself. The waveform and its time delayed replica is correlated by multiplying them together ordinate by ordinate, and then adding the products over the duration of the BAM waveform record. As one would expect the maximum correlation occurs when the time delay τ is zero, and the degree of correlation tends toward zero for random fluctuation waveforms when the time delay is made large, Appendix B. The auto-correlation function is shown plotted against delay time τ for BAM waveform records of run 006 and 018 in Fig 15. Both waveforms have maximum values at zero delay time and both have strong 6.4 - 6.5 Hz quasi-periodic characteristics out to a delay time of 3 seconds. The auto-correlation function is a symmetrical function of delay time τ. The decay of the periodic envelopes with increasing delay time indicates that although the birds of runs 006 and 018 flap their wings rhythmically the waveforms are not strictly periodic and uniform. This lack of uniformity is greater in run 006, where the presence of nulls in the auto-correlation function probably indicate the presence of an additional low frequency periodic signal, which may be due to a recording fault.

A degree of similarity between a reference and unknown waveform can be measured by means of the cross-correlation function, Appendix B. The cross-correlation

function is shown plotted against delay time τ for the two waveforms, run 006 and 018 in Fig 16. The existence of this strong periodic cross-correlation function is proof that in spite of the lack of perfect waveform uniformity runs 006 and 018 are closely related and are practical of the same periodicity 6.4 - 6.5 Hz. The cross-correlation function is not generally a symmetrical function of delay time.

Although correlation offers many advantages for comparing BAM waveforms the advantages are not easily achieved unless the radar echo signals have been fed through a truly linear system. Only with linear signals is it possible to correlate correctly. For example, if a sine wave is fed through a squaring circuit it is not possible to cross-correlate the input and output waveforms of the squaring circuit and obtain a periodic cross-correlation function. Usually echo signals are obtained from the output of the AGC circuit, and this has a non-linear characteristic, which is very approximately logarithmic at high signal levels. Short of using a great variety of test signals of varying levels; correlation methods require the use of receiver channel, which is linear or is linearized. Linearity in this case is not just a straight line relationship between input and output, but the requirement that the input-output relationship creates no new frequency components and fulfills the tenets of the superposition theorem.

5 COMMENTS AND CONCLUSIONS

1 Although it is preferable to observe birds going about their business under natural conditions, these trials demonstrate that it is possible to obtain a worthwhile file of radar flight and echo results from trapped and released wild mallard.

2 Many of the problems of acquiring, tracking and auto-following released birds with a high-resolution radar can be solved by choosing the right release site as explained in the text. Even with a near ideal site it is necessary to release a number of birds to discover their "on site" behaviour and to establish a suitable operating drill. Three different release sites were tried in these trials and all of them had serious drawbacks, but it was still possible to obtain good radar data from 30 out of 80 released birds.

3 Most of the released mallard made short, relatively fast, low-level flights to the sea, but the automatic following and recording radar taking 1000 three-dimensional positions and echo samples per second enabled records of 3 to 200 seconds duration to be made.

4 The released birds generated radar data which fluctuated very much more than that from birds on migration.

5 The mallard flew at airspeeds in the range 30 to 40 knots, but in the shallow dive to the sea airspeeds of 43 to 53 knots were reached. RRE records of duck in level flight give a range of 25 to 45 knots in winds of less than 5 knots, but other workers have reported airspeeds of just more than 55 knots on released duck(9).

6 The "average" static radar echoing areas ± 20 degrees about the broadside aspect, range from 87 sq cm (vertical polarisation) for a duck with

50

closed wings to 122 sq cm (horizontal polarisation) for a drake with closed wings. A good approximation for the static REA averaged over 360 degrees in azimuth is 40 sq cm for either sex irrespective of wing position or aerial polarisation. The REA measurements were made at a radar wavelength of 10 cm.

7 The "average" dynamic broadside REA obtained on one of the mallard was 56 sq cm for vertical polarisation and a radar wavelength of 5.5 cm.

8 The bird activity modulation waveform records of released birds although subject to fluctuations were quasi-periodic, and produced spectra with funamental frequencies in the range 6.3 to 6.9 Hz with mean value approximately 6.5 Hz. Calibrated cine-camera records of mallard have produced values of wing beat frequency in the range 6.2 to 7 Hz. The chief harmonics of the BAM records were the second and third. The effect of large fluctuations in the envelope of the BAM waveform were for the amplitude and response width of the fundamental or harmonics to vary with time, and for the fundamental or harmonics to be absent from time to time.

9 Two radar records of unidentified birds with characteristics similar to duck are given for comparison purposes. These birds were obtained late on an October night at radar ranges of 14 to 18 nautical miles, and flying at fairly constant heights of 4600 and 5200 ft, respectively. Both birds were heading roughly SW into wind and flying at airspeeds of 30 to 32 knots. The BAM waveforms generated by these birds are complex periodic waves and their spectra contained a fundamental and second and third harmonics. The fundamental frequencies are 6.4 and 6.5 Hz. The fundamental components are present throughout the duration of the whole BAM waveform records and the spectral responses are much narrower in width than those of the released mallard.

10 The use of auto-correlation for searching for a BAM waveform of unknown periodicity hidden in noise and cross-correlation for comparing two periodic BAM waveforms are discussed and examples are given.

ACKNOWLEDGEMENTS

The author would like to thank the following for their help and advice: their colleagues of the Wildfowl Trust; the Photographic Unit RRE, the Illustration Unit, RRE; and the Instrumentation Range, RAE. They would specially like to commend the efforts of the RAE radar teams who made it possible to obtain mallard characteristics and George Newlands, RAE who was responsible for much of the data reduction and computing.

Contributed by permission of the Directors of RRE and the Wildfowl Trust.

REFERENCES

1 Boyd, H and Ogilvie, M A : "The distribution of Mallard ringed in southern England", Wildfowl Trust Ann Rep 12, 1961, p125-136.

REFERENCES

2	Matthews, G V T	:	"Some parameters of 'nonsense' orientation in Mallard", Wildfowl Trust Ann Rep 18, 1967, p88-97.
3	Szijj, J	:	"Some suggested criteria for determining the international importance of wetlands in western Palearctic", Proc Inst Conf Wetlands and Waterfowl, Ramsar 1971; p111-124.
4	Houghton, E W	:	"REAs of Flying Animals", AGARD Lecture Series 59, Oslo, October 1973, p 2(b)-1
5	Houghton, E W	:	"Radar Track of two Crows", Unpublished MOD (PE) Memorandum.
6	Houghton, E W and Brough, T	:	"Estimating the physical dimensions of birds by radar", BSCE, 9th Conf, Frankfurt, 1974, Chapter 4.15
7	Blackwell, F; Houghton E W; and Wilmot, T A	:	"Analysis and Classification of Bird Flight and Echo Data obtained by Radar", Bird Strike Committee Europe, 9th Conference, Frankfurt, 1974, Chapter 4.14
8	Bendat, J S and Piersol, A G	:	"Random Data", Wiley-Interscience, New York, 1971, chapters 8-9, p256-333.
9	Houghton, E W; Blackwell, F and Wilmot, T A	:	"Bird Strike and the Radar Properties of Birds", Radar - Present and Future, IEE Conference No 105, London 1973, p258.

TABLE 1

SPEED CHARACTERISTICS OF RELEASED MALLARD

RUN No	FLIGHT TIME (sec)	CHANGE OF HEIGHT	GROUND SPEED (ft/sec)	AIR SPEED (ft/sec)
L1	24 - 34	"CONSTANT"	74	61
H1	4 - 8	"CONSTANT"	75	66
G1	10 - 22	"CONSTANT"	60 (35.5 kts)	60 (35.5 kts)
A2	3 - 11	"CONSTANT"	81	66
C2	0 - 20	"CONSTANT"	84	66
B2	3 - 13	"DIVE" (5 ft/sec)	84	77
E2	20 - 34	"DIVE" (7 ft/sec)	98	87
L2	6 - 17	"DIVE" (12 ft/sec)	94	86
M2	68 - 80	"DIVE" (5 ft/sec)	76	63
J2	0 - 11	"DIVE" (7 ft/sec)	85	72
R2	10 - 20	"DIVE" (9 ft/sec)	103 (60.9 kts)	87 (51.5 kts)
U2	0 - 13	"DIVE" (5 ft/sec)	95	77
	13 - 26	"DIVE" (11 ft/sec)	100 (59.2 kts)	79 (46.7 kts)

Wind speeds at 500 ft for runs -1, 15 ft/sec, bearing 083 degree

and for runs -2, 27 ft/sec, bearing 090 degree.

All characteristics taken over "straight" portions of the radar plan position tracks.

APPENDIX A(1)

FILTERING COMPLEX WAVEFORMS

In this and a previous paper (7) the use of bandpass filters to separate the fundamental and the hramonic components of a complex BAM waveform has been mentioned. We shall now consider some precautions to be taken when using this method.

A complex waveform can be analysed by feeding it through a number of bandpass filters tuned to the fundamental and the harmonic components. The bandwidths of the filters will have to be narrow if the harmonics are closely spaced. What effect has bandwidth on the fundamental and harmonic responses if the envelope of the complex wave fluctuates in amplitude?

Complex BAM waveforms and their filtered components are shown in Fig. 8A, 9A, 10A, 11A, 12A and 13A. The top waveform in Fig. 9A is the complex BAM waveform straight from the radar receiver's AGC line after being fed through a lowpass filter with a passband from 0 to 40 Hz. The bottom waveform in Fig. 8A is the fundamental component of the complex BAM waveform after being fed through a bandpass filter of 1 Hz bandwidth and tuned to a centre frequency of 6.5 Hz. The waveforms above the fundamental are the second and third harmonics components after being fed through bandpass filters of bandwidths 2 and 3 Hz, and tuned to centre frequencies of 13 Hz and 19.5 Hz, respectively.

Obviously it would be very difficult to understand the filter behaviour by considering complex waveforms such as Fig. 8A. The filtering and transient properties of a filter can be explored by using complex waveforms with known parameters. The low pass and three bandpass filters used to filter out the complex BAM waveform have been tested with three known waveforms, and their responses are shown in Fig. 14A, 14B and 14C.

The transient response of the filter can be considered very practically in terms of the delay time and the rise time. The delay time is given by the time delay between the 50% amplitude at the start of the test pulse and 50% amplitude at the start of the filtered pulse. Delay time is given by the expression $T_d = C/B$, where C is a constant which is dependent on the number of stages and type of filter and B is the ½ power bandwidth of the filter. C is generally about unity or more if a large number of stages are used in the filter. Rise time is measured between 10% and 90% amplitude at the start of the pulse and it can be expressed by $T_r = K/B$, where K is unity or less for bandpass filters and 0.5 or less for low pass filters.

A 6.5 sinusoidal waveform was switched quickly on and off to provide a 3 second pulse and this waveform was fed through the lowpass and the three bandpass filters. The lowpass filter has scarcely any effect on the waveform and this is shown by the top waveform in Fig. 14A. Only the fundamental component at 6.5 Hz is present as there are no harmonics. The filtered pulse has a delay time of just less than one second and the rise time is also just less than one second as might be expected from the bandwidth of 1Hz. The effect of using a more complex waveform, a pulsed rectangular wave, is shown in Fig. 14B. The relative amplitudes of the fundamental and third harmonic components of the rectangular wave are approximately unity and 0.33, and

there are no even harmonics. The transient response of the fundamental filter is similar to that obtained of the pulse sine wave, but the delay and rise time of the third harmonic is now only a fraction of a second because the filter bandwidth is 3 Hz. The effect of an even more complex waveform, a pulsed sawtooth waveform is shown in Fig. 14C. The ideal sawtooth wave has both odd and even harmonics and the relationship between amplitudes is unity, 0.5 and 0.33 for fundamental, second and third harmonics as shown in Fig. 14C. The pulse response is most pronounced for the narrowest bandwith and least for the broadest bandwidth of the third harmonic filter.

Thus we find that a relatively narrow bandwidth delays the pulse and slows down the rise time more than if a wider bandwidth is used. In the case of the bird waveforms under consideration it would have been preferable to use similar bandwidths for fundamental and harmonic filters so that delay times would have been approximately the same. A wider bandwidth of at least 3 Hz for the fundamental and 2nd harmonics would have reduced rise time distortion too, but unfortunately the bandwidths of the tunable filters used in these experiments were not adjustable. Poor transient response does not affect the filtering out of the spectra, but makes it difficult to compare the fluctuation characteristics of fundamental and harmonic waveforms.

APPENDIX B(1)

CORRELATION

Correlation is a mathematical method of computing the degree of similarity between two quantities. Electrical quantities, such as voltage waveforms used in communications, radar and medical diagnostic equipment are particularly convenient, because waveforms can be easily manipulated with respect to time. Auto-Correlation is a method of correlating a waveform with a time shifted replica of itself, and Cross-Correlation is the process of correlating two waveforms which may have come from different origins. The theory and practice of correlation measurements employing electrical waveforms are well explained in a book by Bendat and Piersol (8).

The Auto-Correlation Function $\emptyset(\tau)$ of a waveform $x(t)$ is given by the expression:-

$$\emptyset(\tau) = \overline{x(t)\ x(t+\tau).dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and if the waveform $x(t)$ is a continuous function it can be written

$$\emptyset(\tau) = \lim_{T\to\infty} \int_{-T}^{+T} x(t).x(t+\tau).dt \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where τ is the delay time, T is the integration or averaging time and

$$0 \leq \tau < T$$

In other words, the auto-correlation function is obtained by multiplying the value of waveform $x(t)$ at any instant by the value of the replica $x(t + \tau)$ occurring τ seconds later. The instantaneous product values being averaged over time T in which the waveforms are being compared.

The auto-correlation function is generally plotted against delay time τ as in Fig. 15. Auto-correlation functions are symmetrical functions of delay time and so they are plotted for positive and negative values of delay time about zero delay ($\tau = 0$) axis. The peak value of the auto-correlation function $\phi(\tau)$ occurs at that point and it is proportional to the mean square amplitude, since from equation (2).

$$\phi(\tau) = \frac{1}{2T}\int_{-T}^{+T} x^2(t)\,dt \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Auto-correlation is especially useful in searching for a periodic waveform like a bird's wingbeat "signature" (eg, which may be badly mutilated by erratic REA aspect changes or because it is a weak echo signal buried in receiver noise), since no a priori knowledge of the wing-flapping periodicity is required.

For example, assume waveform $x(t)$ is the combination of a periodic waveform $s(t) = A\cos wt$ plus a receiver random noise waveform $n(t)$ of zero mean.

We can write using equation (2):-

$$\phi(\tau) = \frac{1}{2T}\int_{-T}^{+T} [A\cos w\,(t+\tau)+n(t+\tau)][A\cos wt + n(t)]\,dt \quad \ldots\ldots\ldots\ldots (4)$$

and this equation can be reduced to

$$\phi(\tau) = \phi_{ss} + \phi_{nn} + \phi_{ns} + \phi_{sn} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where the right hand side terms are auto-correlation functions of signal and noise, and cross-correlation functions of signal and noise. It can be shown that if signal and noise are independent quantities, the cross-correlation terms are zero for all values of delay time τ and only the terms of interest ϕ_{ss} and ϕ_{nn} remain.

Taking the case where the combined periodic signal plus noise has been fed through a resistance-capacity filter we can write:-

$$\phi_{ss} = A^2/2\cos w\,\tau \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\phi_{nn} = a\exp(-b\tau) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

And equation (5) can be reduced to:

$$\phi(\tau)\rightarrow\phi_{ss} \quad \text{as} \quad \phi_{nn}\rightarrow 0$$

by increasing the value of the delay time τ to a relatively large value.

Thus if the delay time is increased to a relatively large value the value of $\phi(\tau)$ falls from its peak at zero delay until it reaches a value which is periodic and wholly dependent upon the periodic function ϕ_{ss} given by equation (6). Consequently, a periodic signal of period (w) buried in noise can be recovered by using correlation techniques.

An even better way of searching for a periodic signal concealed by a fluctuating signal is possible if the periodicity of the signal is known, and this is by using cross-correlation methods.

The Cross-Correlation Function $\phi_{ij}(\tau)$ of two waveforms y(t) and z(t) is given

$$\phi_{ij}(\tau) = \overline{y(t)z(t+\tau)} \quad \ldots\ldots(8)$$

and if the waveforms are continuous functions we can write

$$\phi_{ij}(\tau) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{+T} y(t)z(t+\tau)dt \quad \ldots\ldots(9)$$

For example, if the signal of interest of known period (w), Acos wt, is hidden by a random signal n(t), we can measure the cross-correlation of the combination with respect to a reference signal R cos (wt + Θ).

Generally, the amplitude R and the phase θ of the reference signal are arbitrary functions and do not need to be known. The cross-correlation function of this periodic plus random signal combination and the reference signal is obtained from equation (9):

$$\phi_{ij}(\tau) = \frac{1}{2T} \int_{-T}^{+T} [A\cos(wt+\tau) + n(t+\tau)]R\cos(wt+\theta)dt \quad \ldots\ldots(10)$$

and this can be reduced to

$$\phi_{ij}(\tau) = \phi_{sr} + \phi_{nr} \quad \ldots\ldots(11)$$

Where the first term on the right hand side is the cross-correlation of the periodic signal with the reference and the second term is the cross-correlation of the random and the reference signals. It can be shown that as the integration time of the measurement is increased towards the limit:-

$$\phi_{ij}(\tau) \to \phi_{st} = \frac{AR}{2}\cos(w+\tau) \quad \ldots\ldots(12)$$

Thus the resultant correlation function is a periodic wave of the same period as the one submerged in random noise. Cross-correlation functions are generally plotted against delay time as in Fig. 16. They are plotted for both positive and negative values of delay time about the zero delay time axis, but

APPENDIX B(4)

unlike auto-correlation functions they are not necessarily symmetrical. A point worth knowing is the removal of the random fluctuation is not dependent upon any limits on the value of delay time.

In the equations given simple sinusoidal periodic waveforms have been used, but complex periodic waveforms such as triangular waves can be treated also.

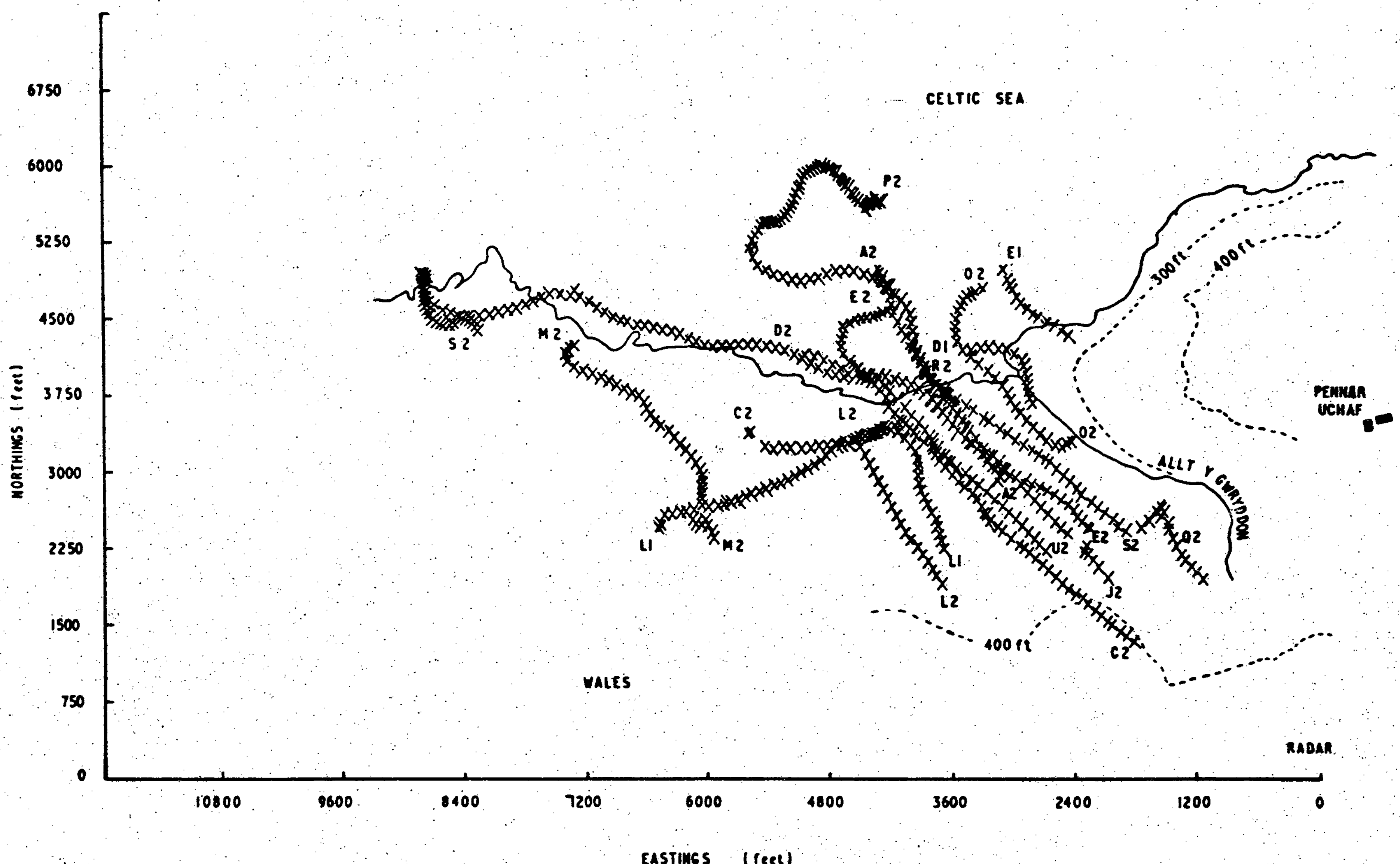


FIG. I.

MAP OF RELEASED WILD DUCK TRACKS

59

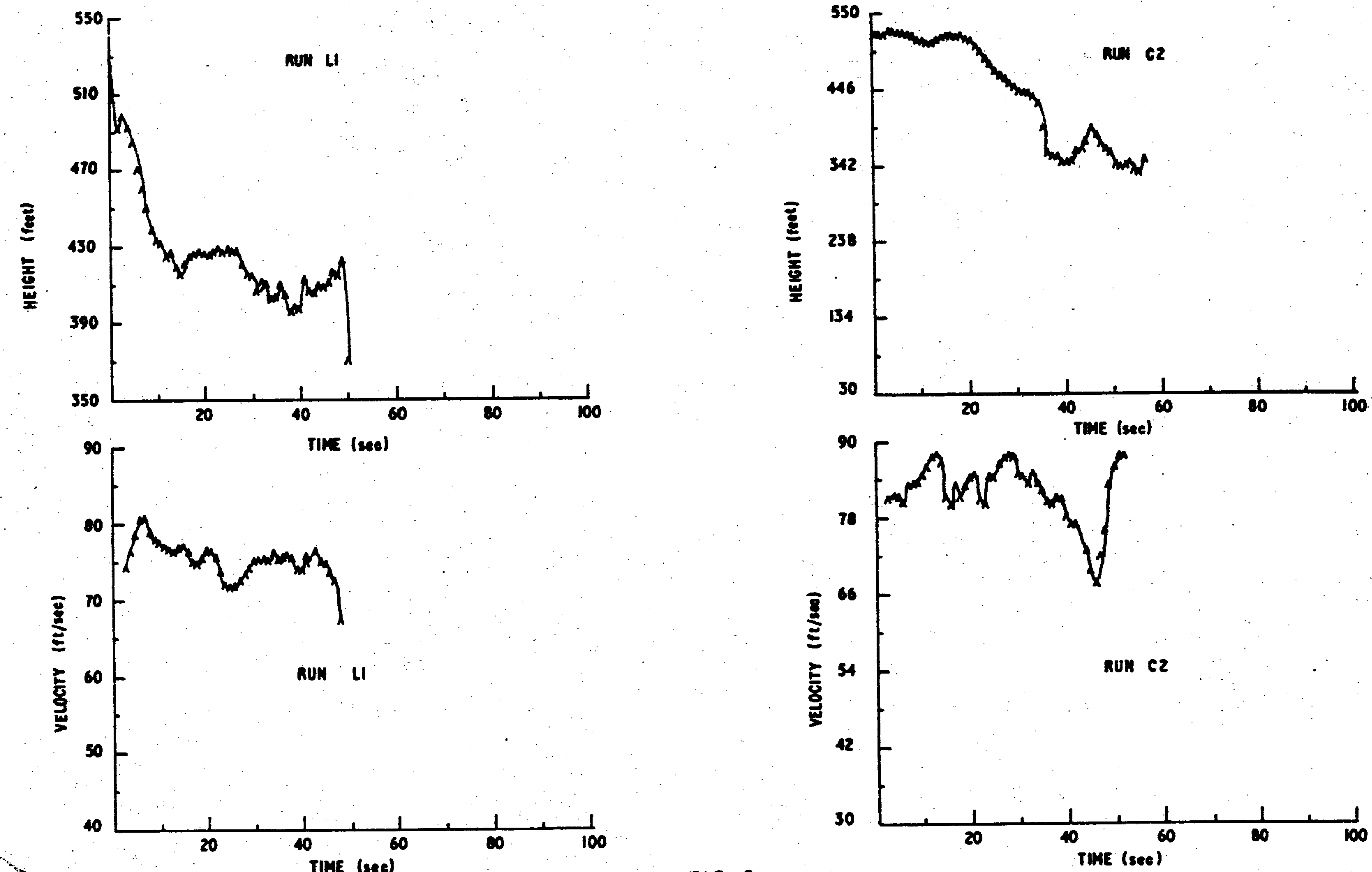


FIG. 2.

HEIGHT - VELOCITY - TIME DIAGRAMS

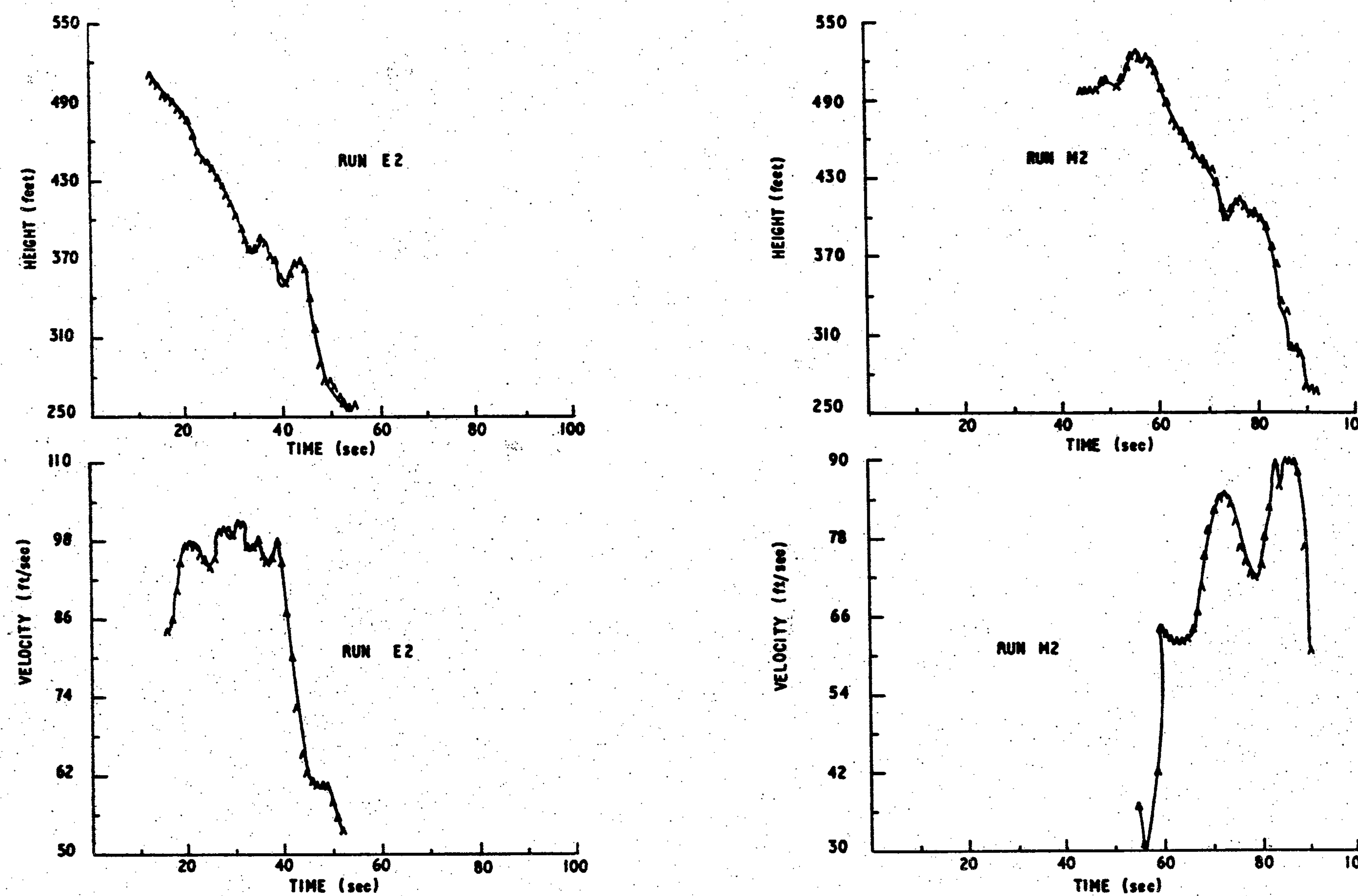


FIG. 3.

HEIGHT – VELOCITY – TIME DIAGRAMS.

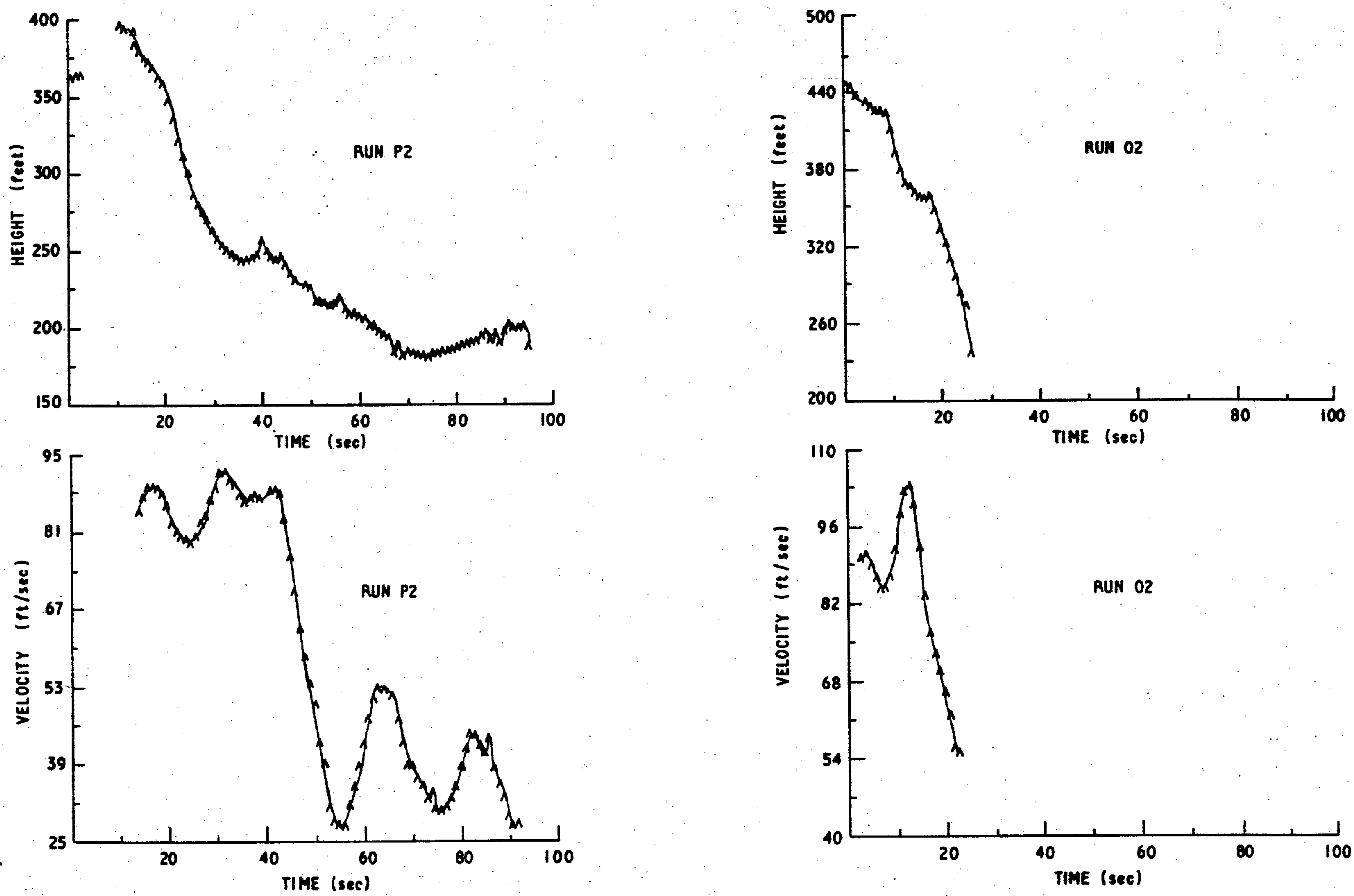


FIG. 4
HEIGHT-VELOCITY-TIME DIAGRAMS

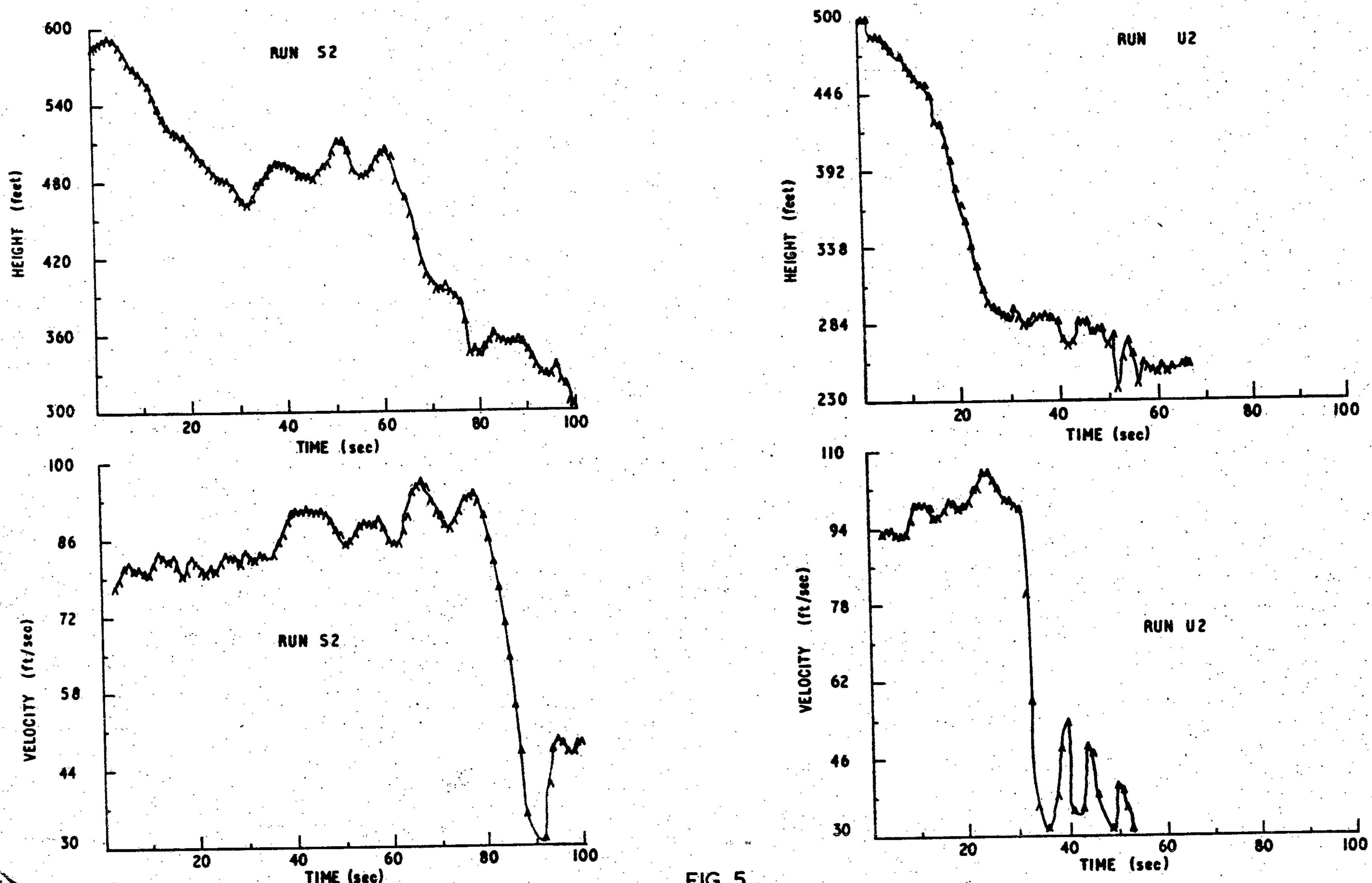


FIG. 5.

HEIGHT - VELOCITY - TIME DIAGRAMS.

63

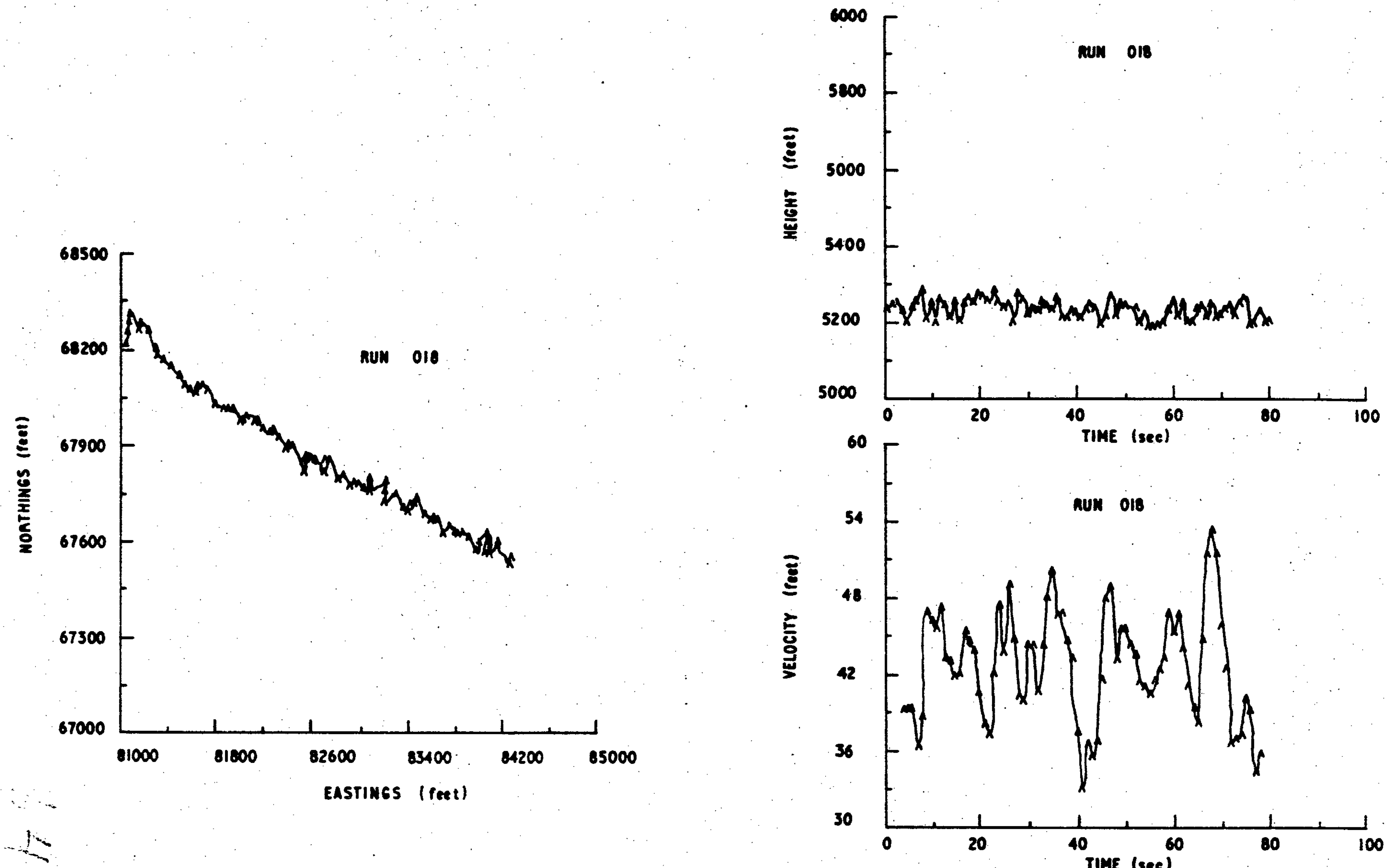


FIG. 6.

MAP AND HEIGHT-VELOCITY-TIME DIAGRAMS.

47

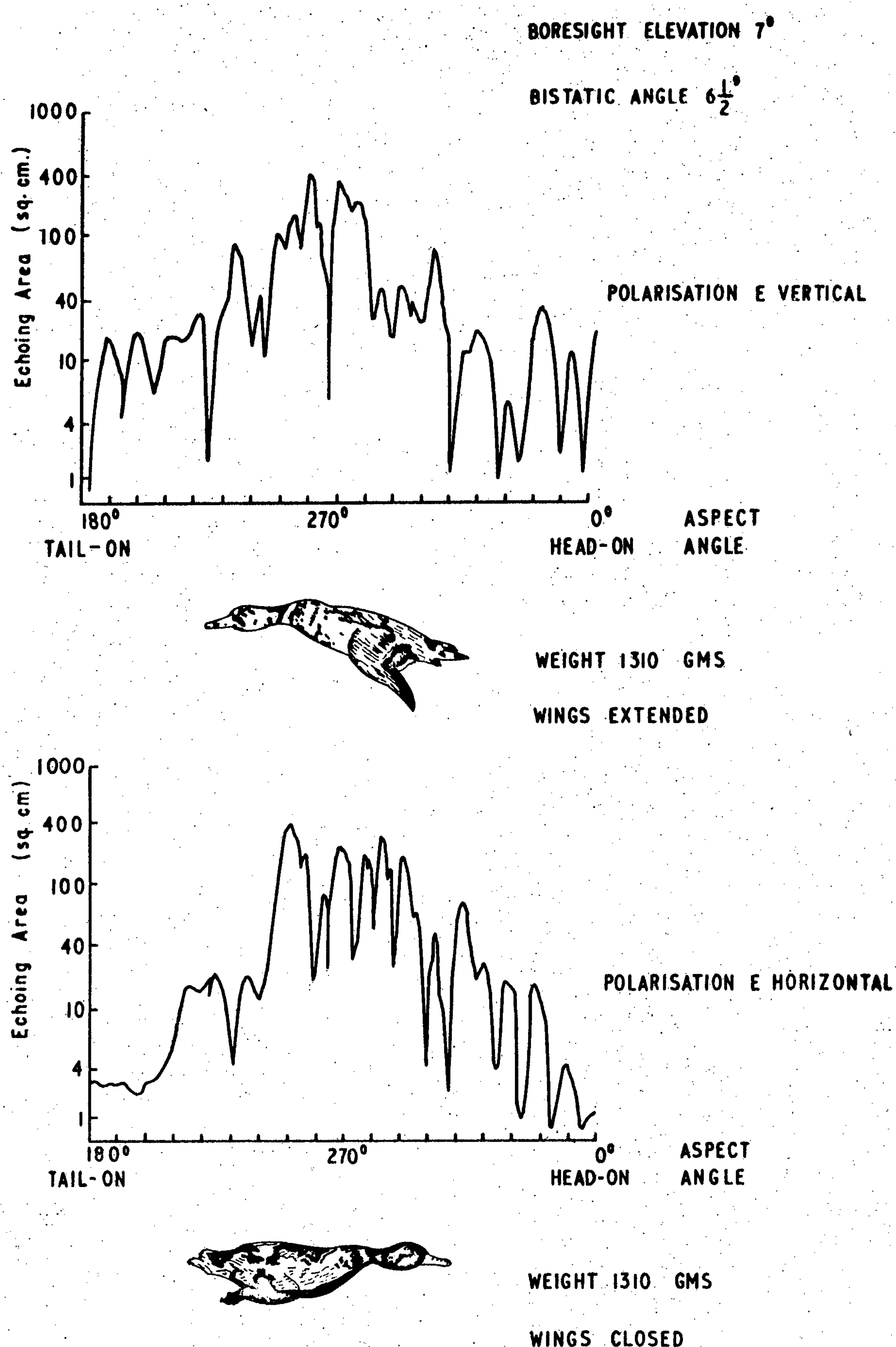


FIG. 7.

RADAR ECHOING AREA DIAGRAMS OF MALLARD

S-BAND (3·85 GHz)

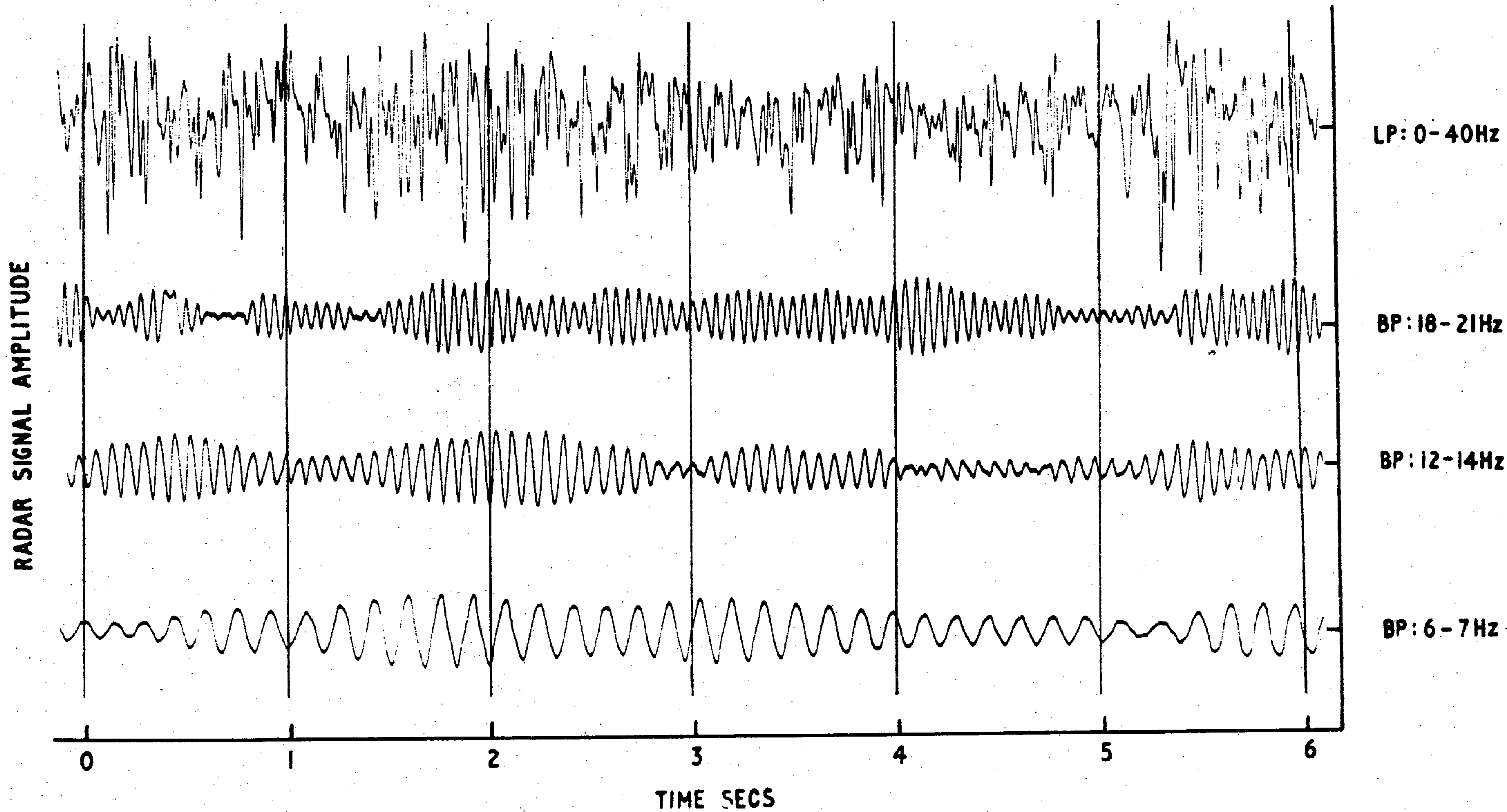
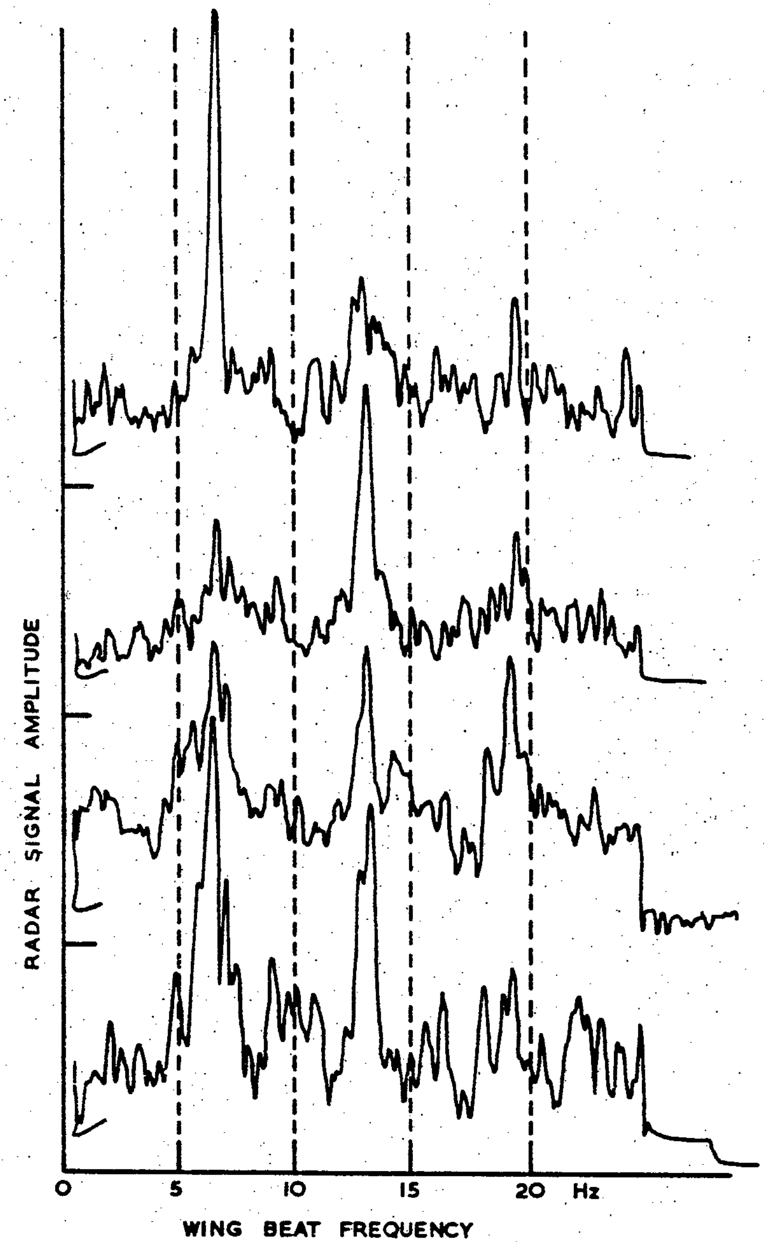


FIG. 8A. BAM WAVEFORM AND CHIEF FREQUENCY COMPONENTS OF RELEASED WILD DUCK RUN C/3/69

66



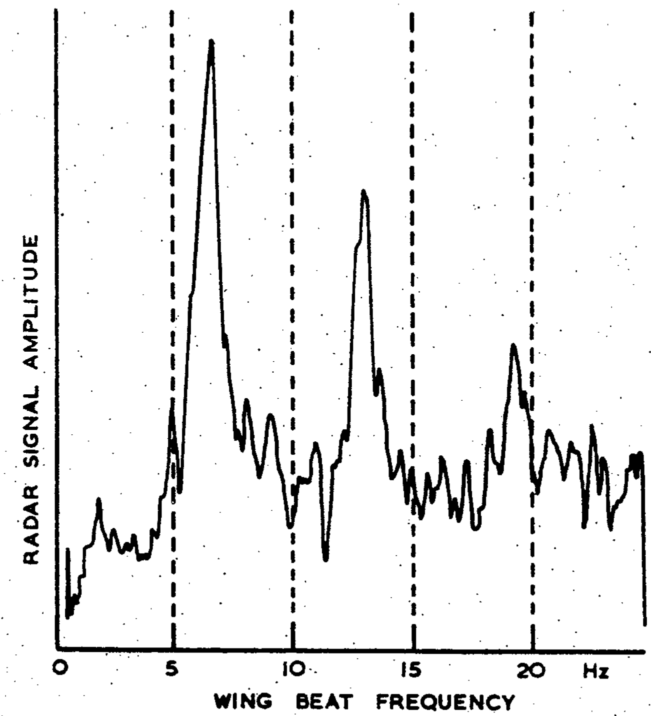


FIG. 8B SPECTRA OF RELEASED WILD DUCK, RUN C/3/69

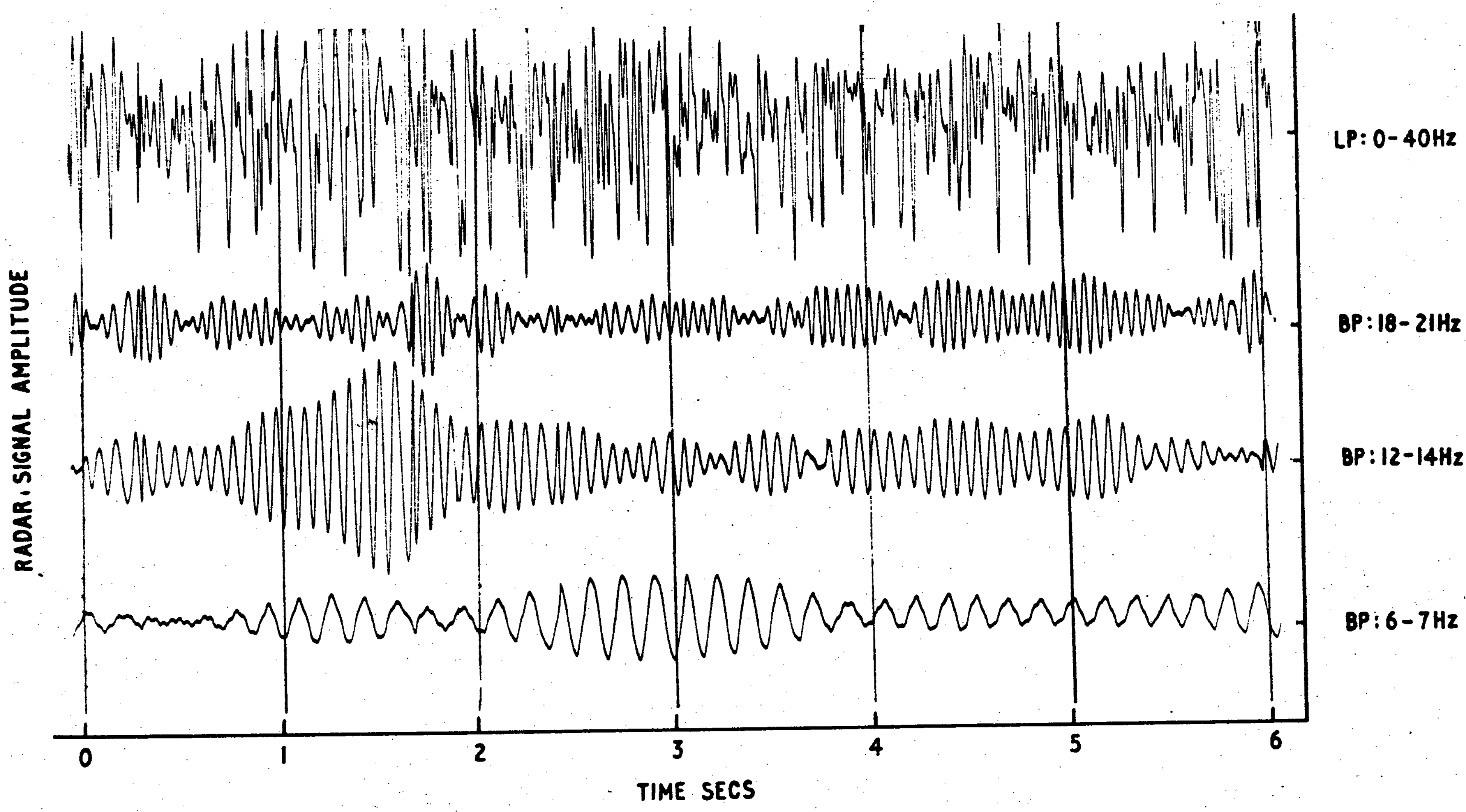


FIG. 9A. BAM WAVEFORM AND CHIEF FREQUENCY COMPONENTS OF RELEASED WILD DUCK <u>RUN L/2/69</u>

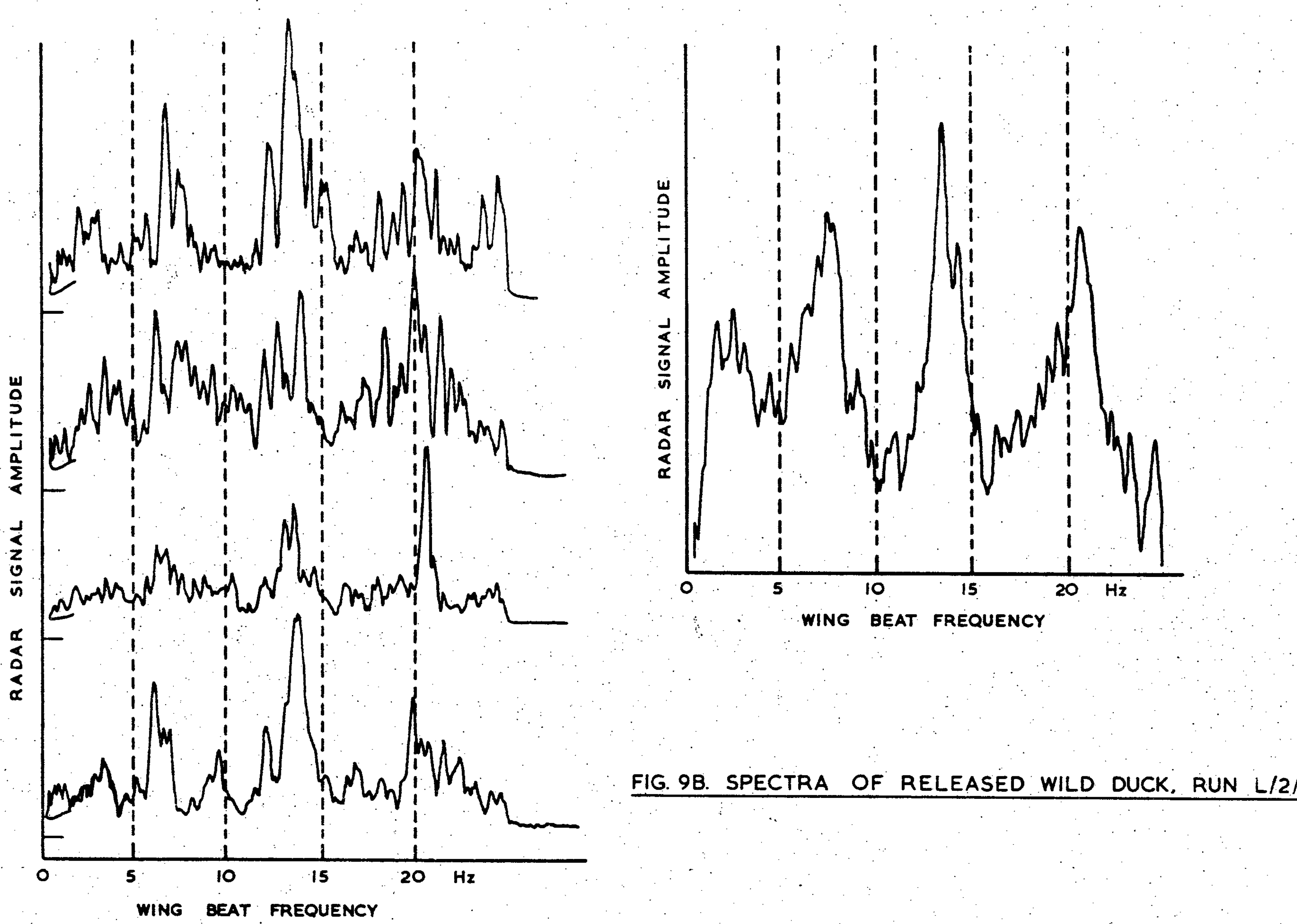


FIG. 9B. SPECTRA OF RELEASED WILD DUCK, RUN L/2/69

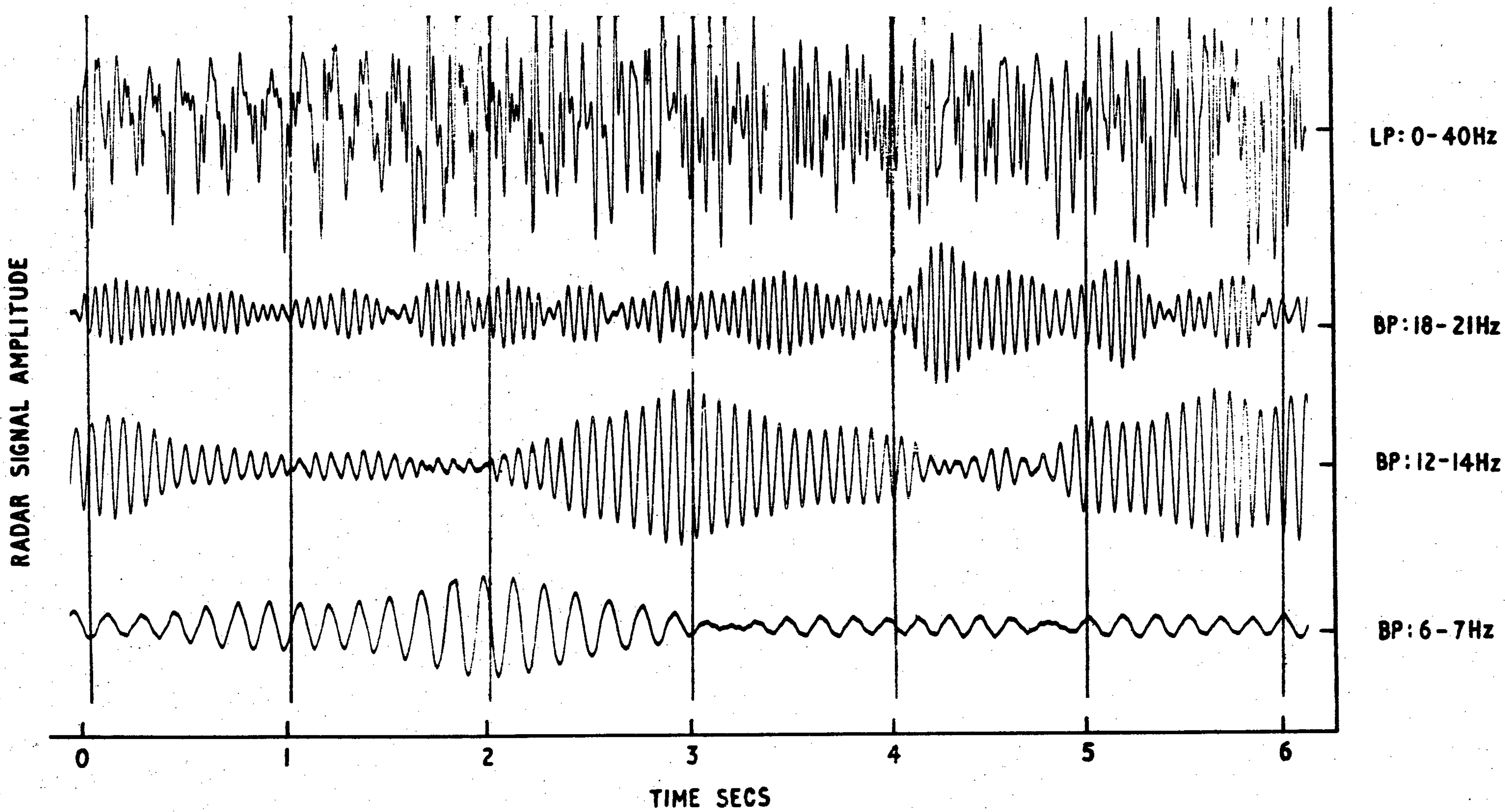


FIG. 10A. BAM WAVEFORM AND CHIEF FREQUENCY COMPONENTS OF RELEASED WILD DUCK <u>RUN P/3/69</u>

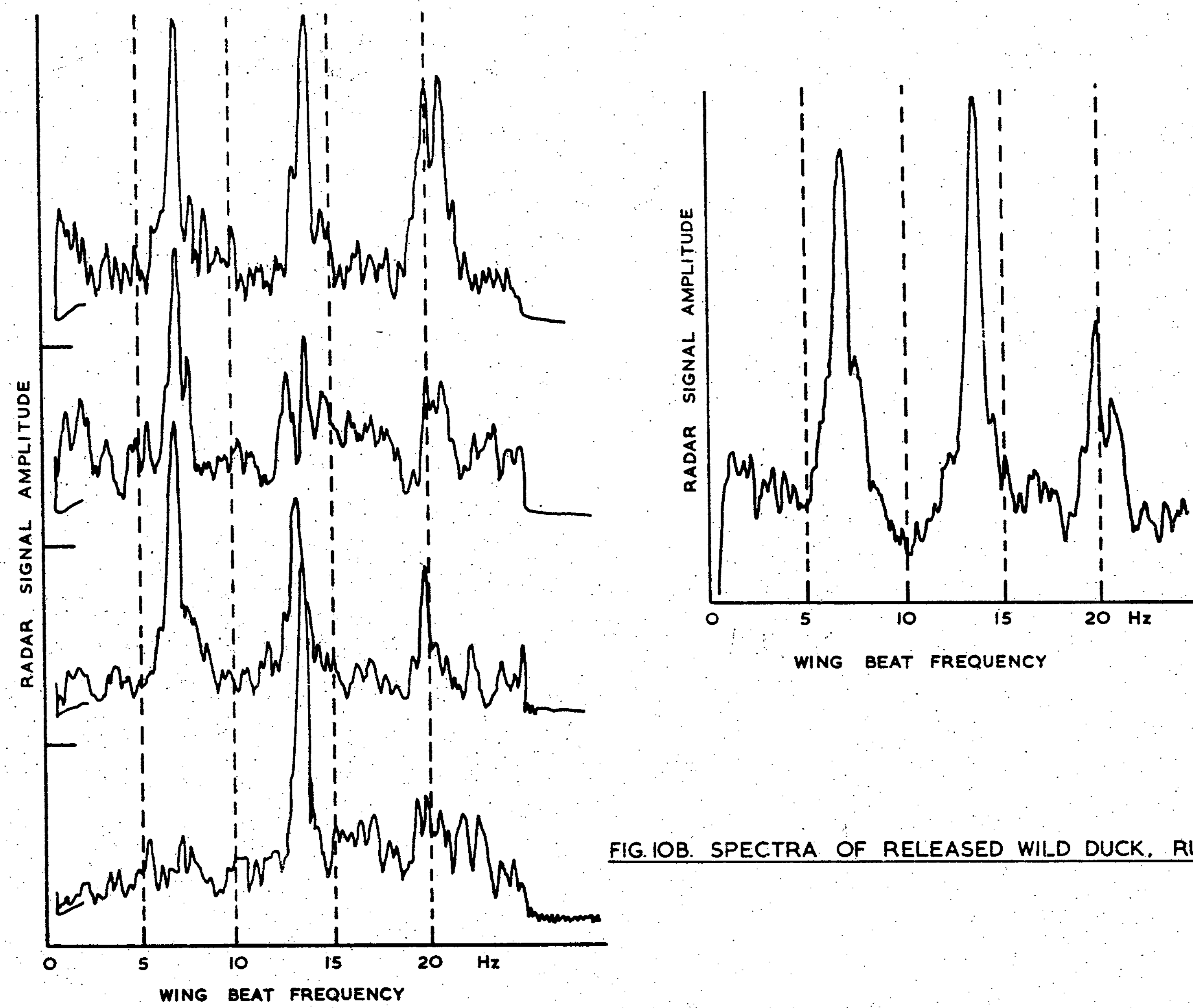


FIG. 10B. SPECTRA OF RELEASED WILD DUCK, RUN P/3/69

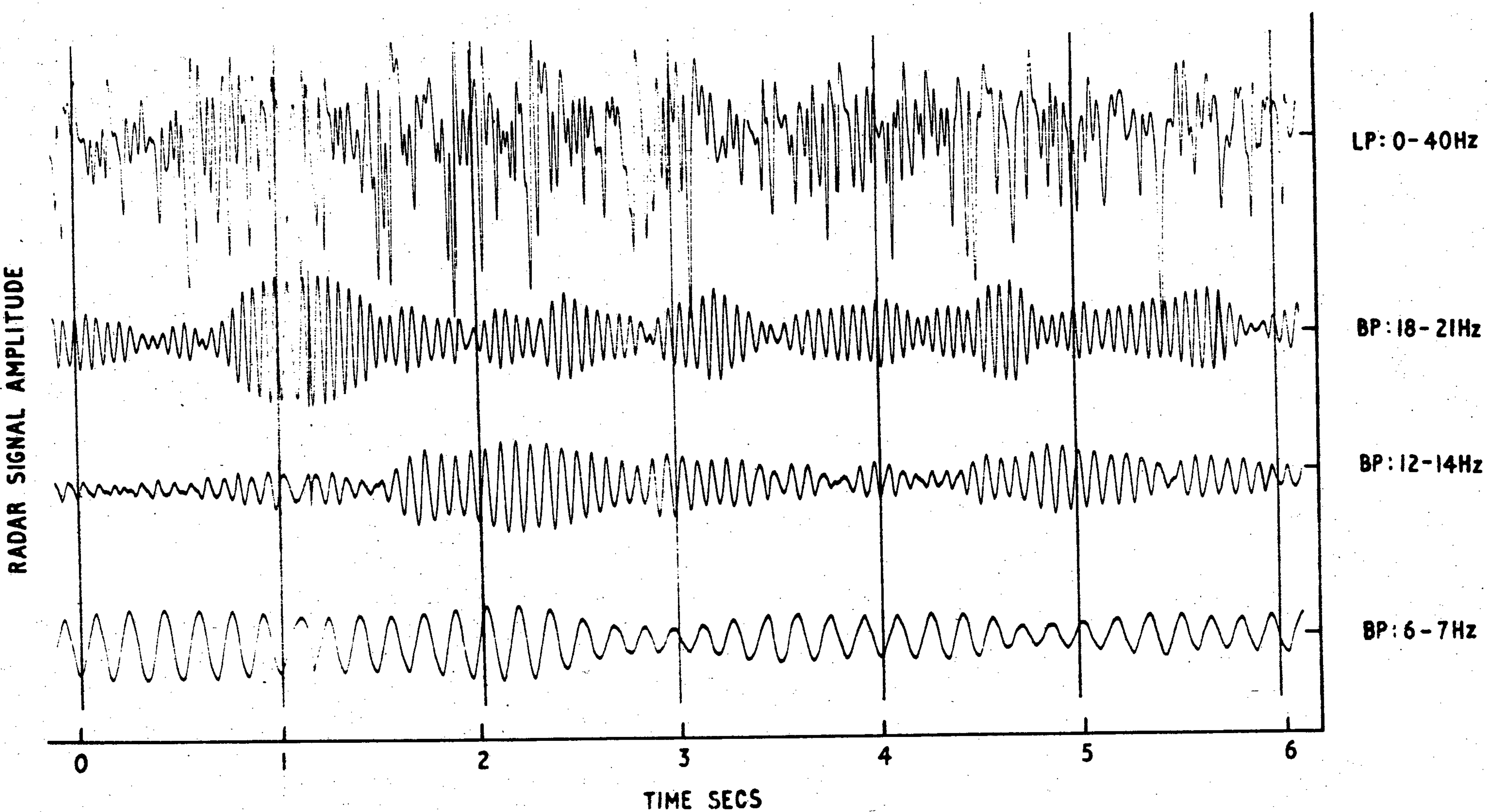
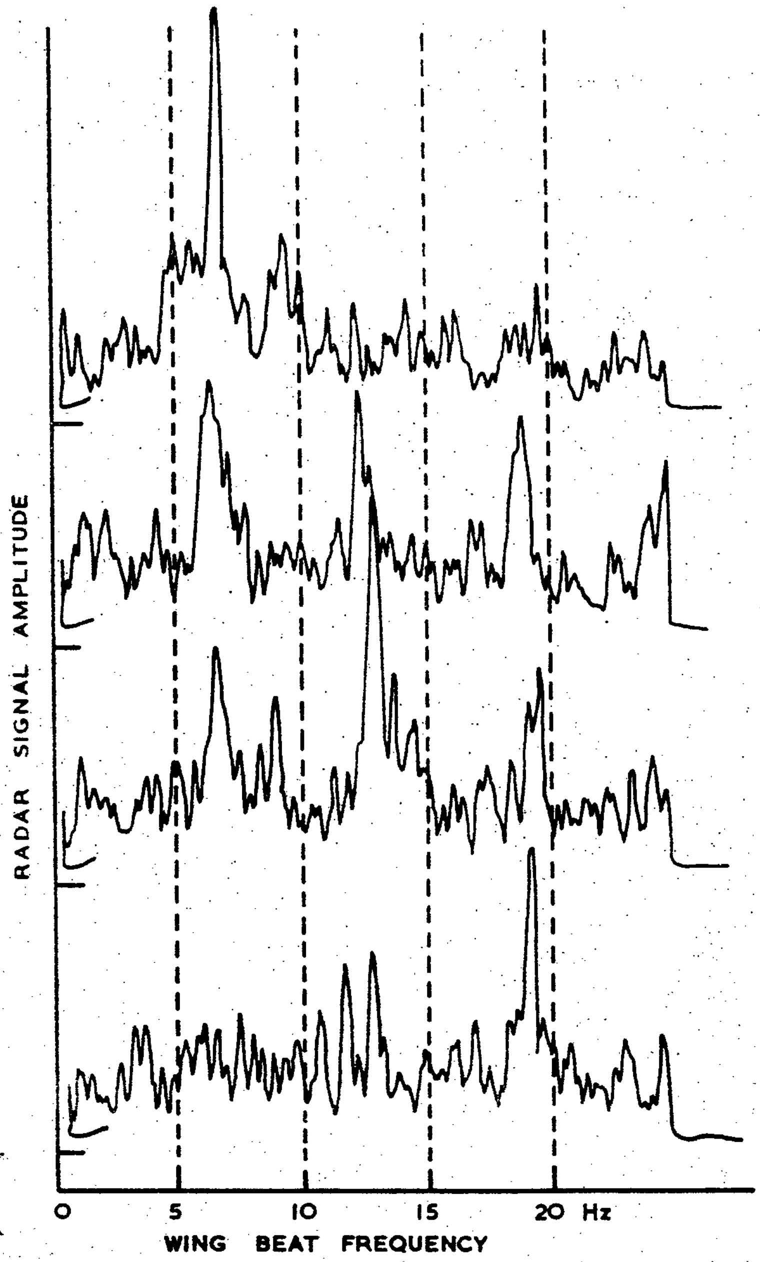


FIG. 11A. BAM WAVEFORM AND CHIEF FREQUENCY COMPONENTS OF RELEASED WILD DUCK RUN S/3/69



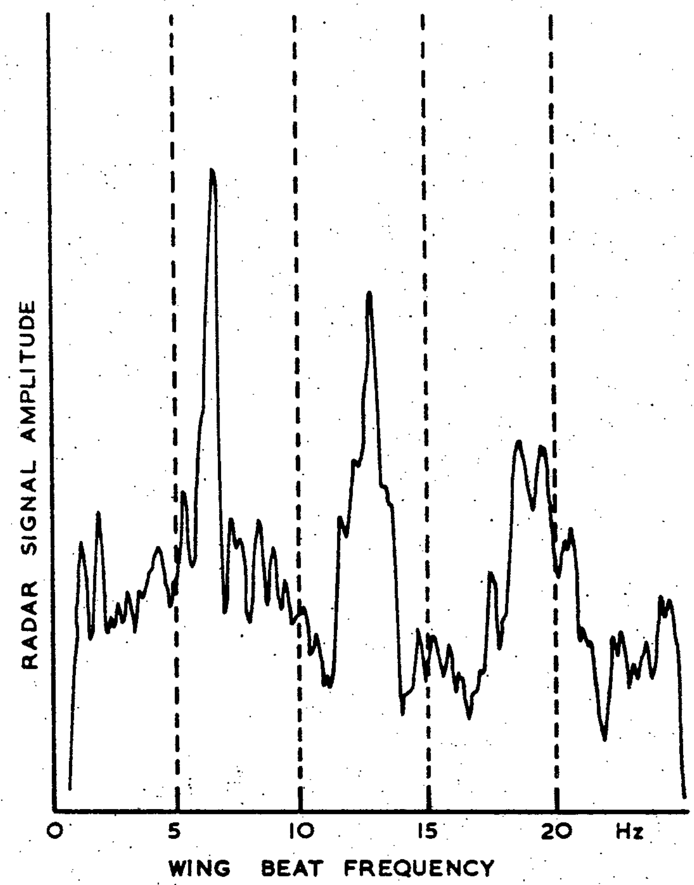


FIG. 11B SPECTRA OF RELEASED WILD DUCK, RUN S/3/69

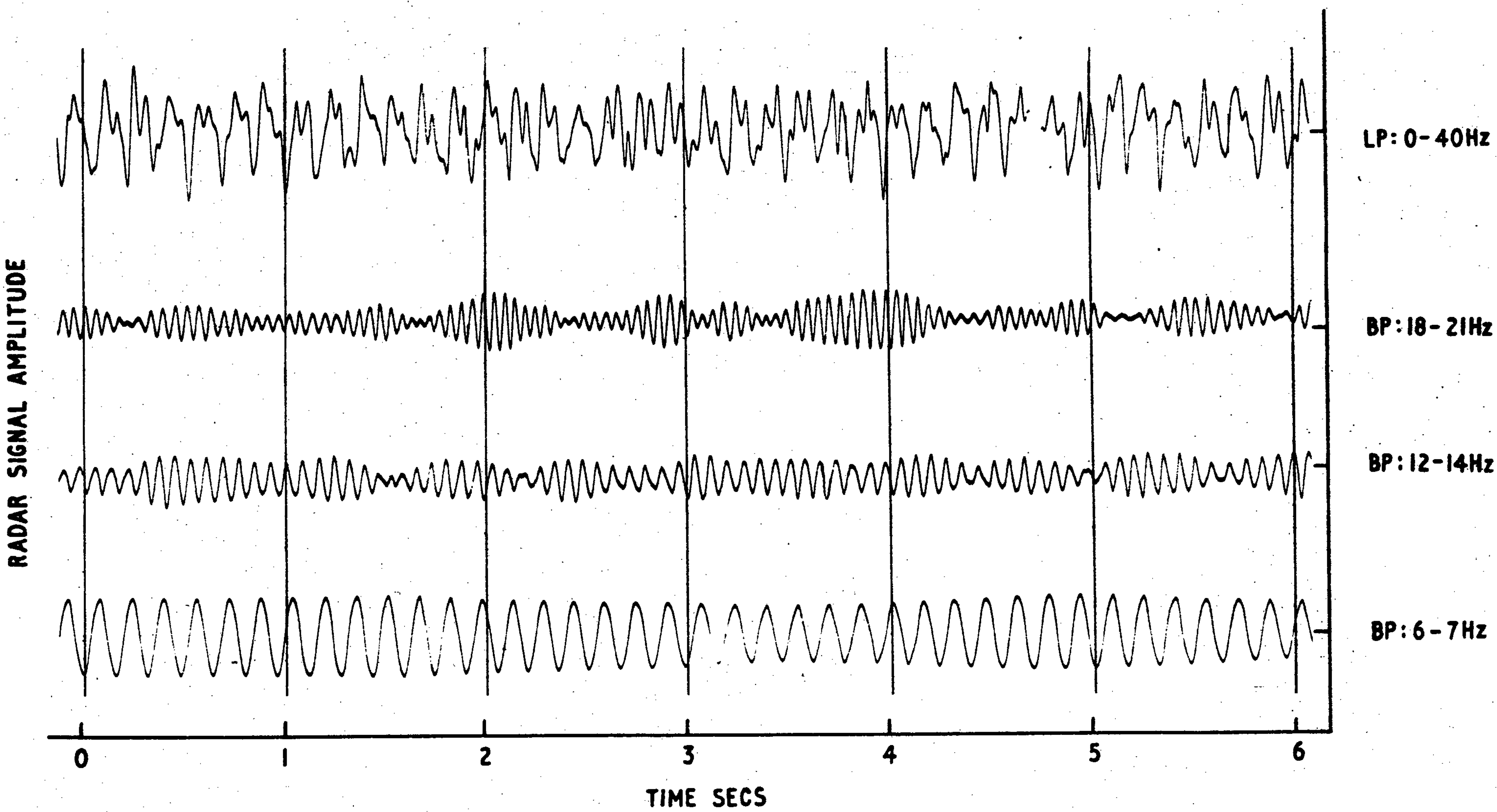
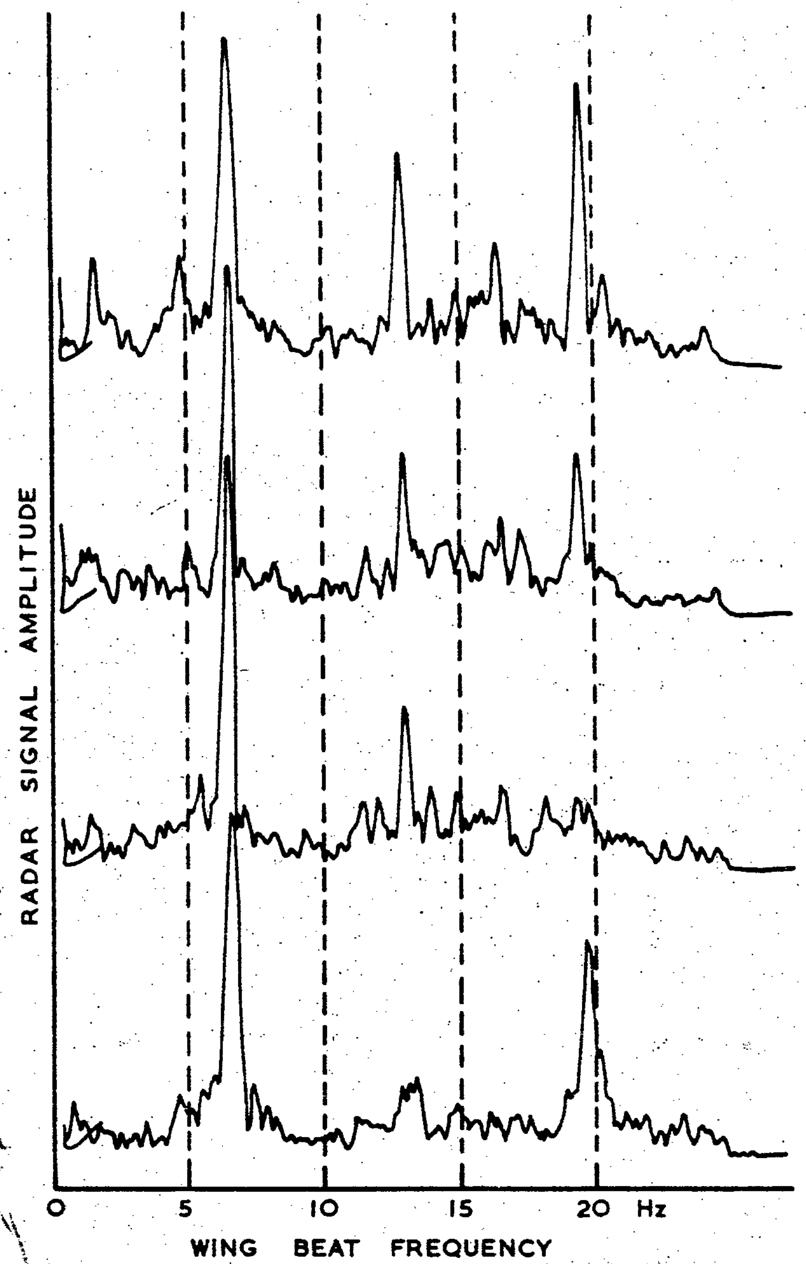


FIG. 12A. BAM WAVEFORM AND CHIEF FREQUENCY COMPONENTS OF MIGRATING DUCK RUN 6/68



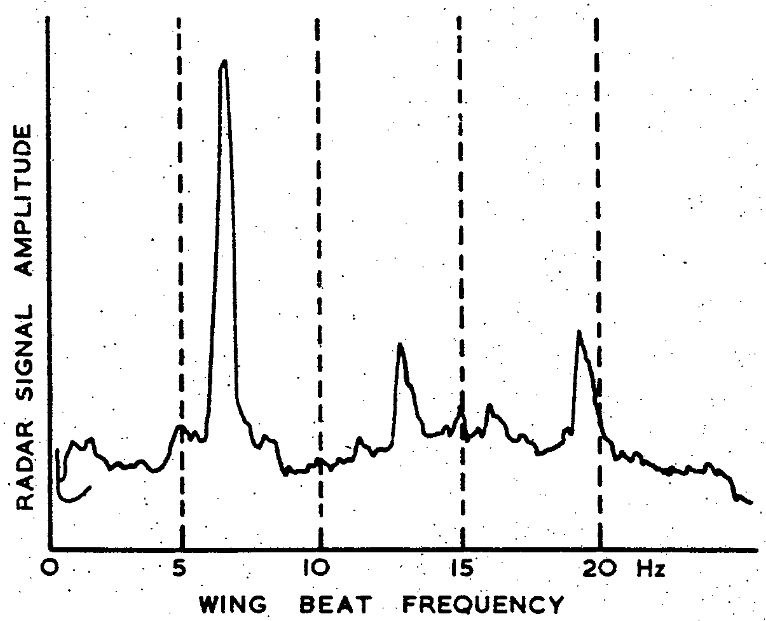


FIG. 12B SPECTRA OF MIGRATING DUCK, RUN 6/68

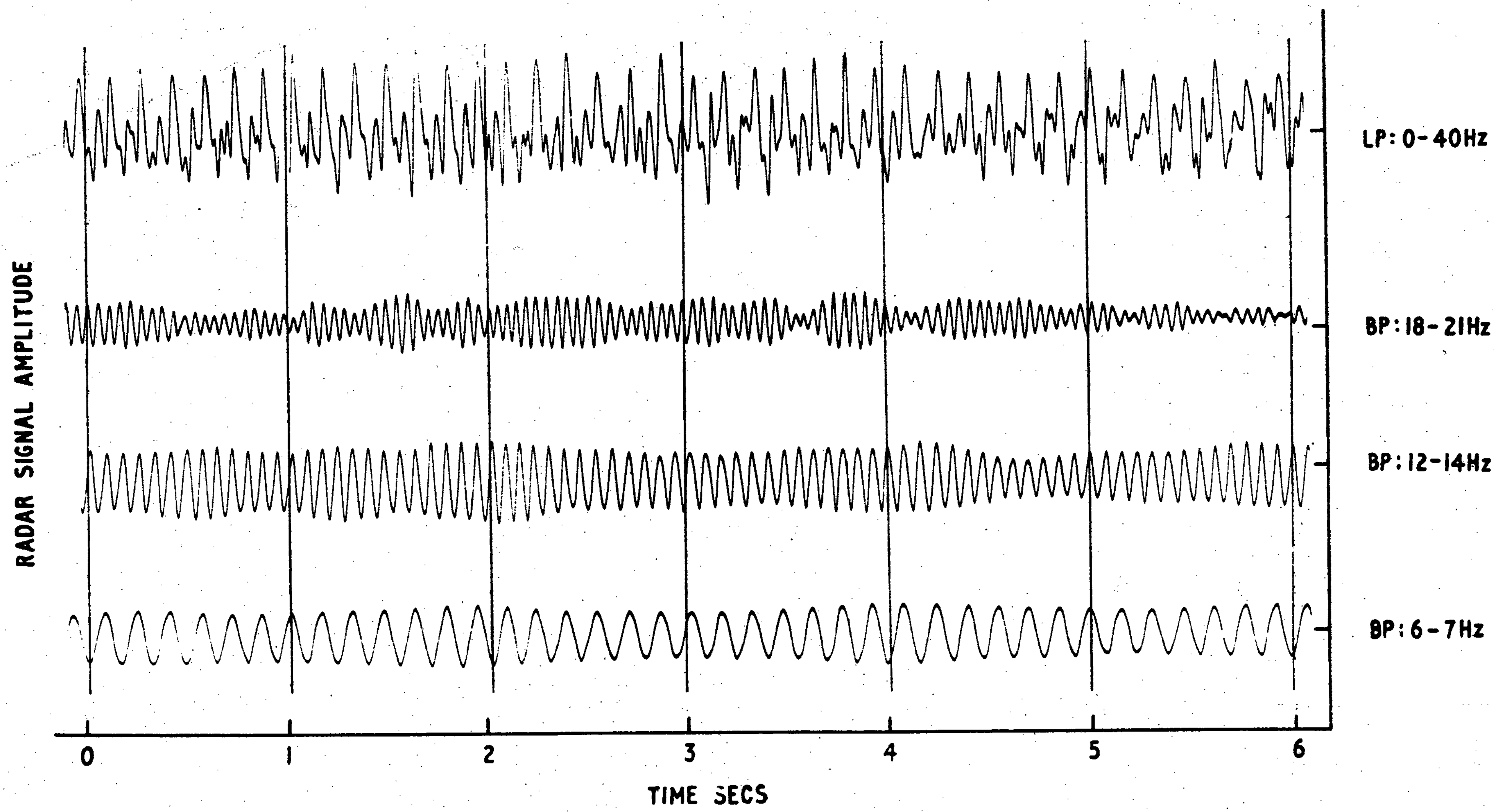


FIG. 13A. BAM WAVEFORM AND CHIEF FREQUENCY COMPONENTS OF MIGRATING DUCK RUN 18/68

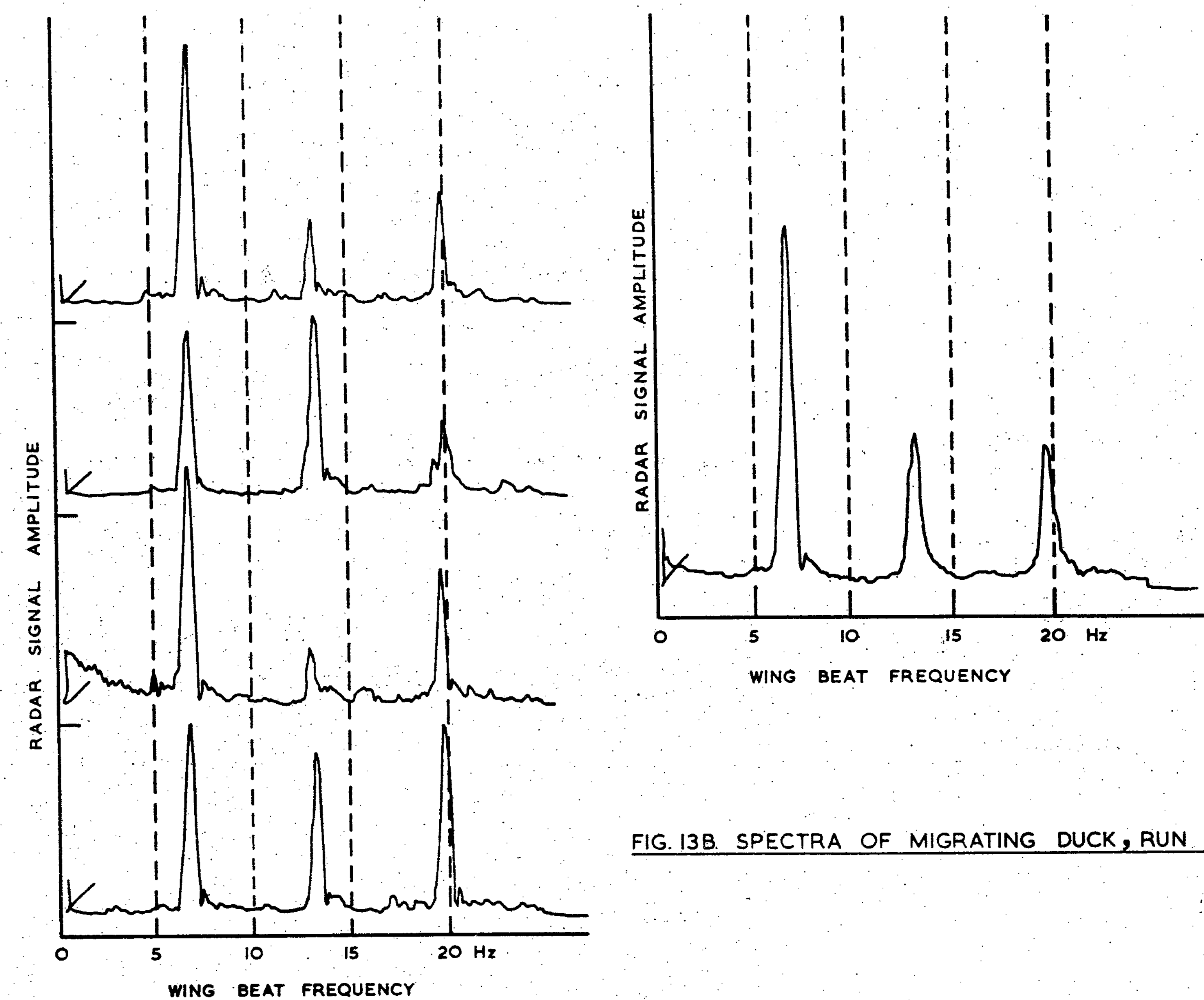


FIG. 13B. SPECTRA OF MIGRATING DUCK, RUN 18/68

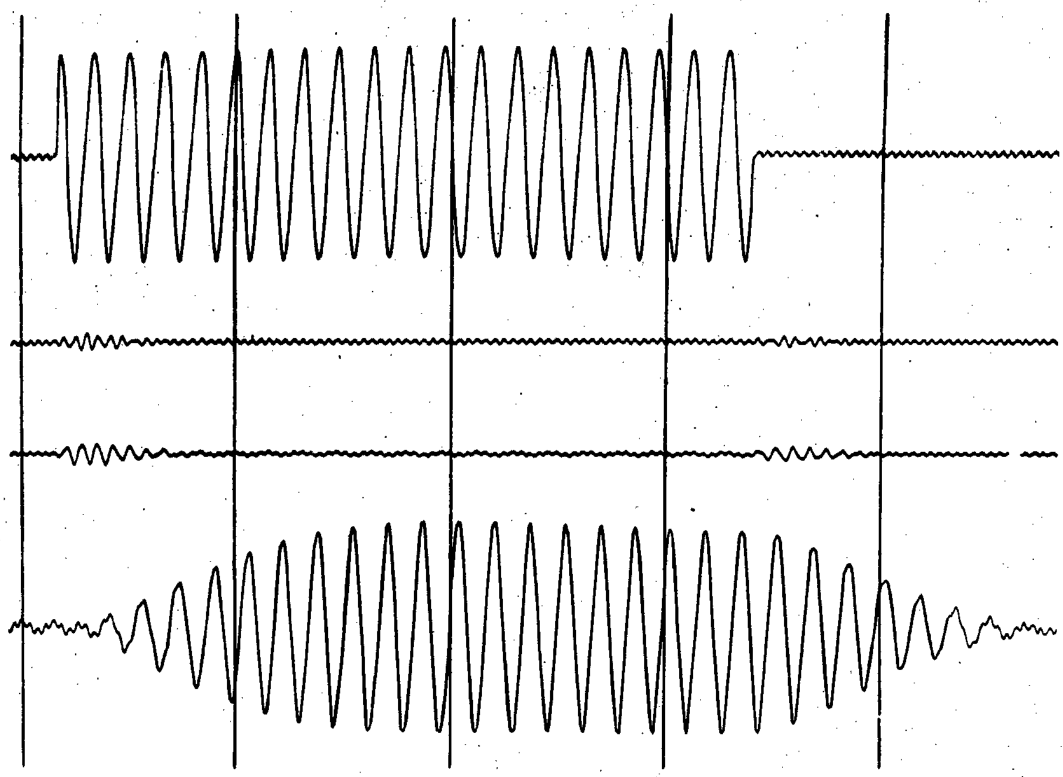


FIG. 14A. PULSED SINE WAVEFORM AND CHIEF FREQUENCY COMPONENTS

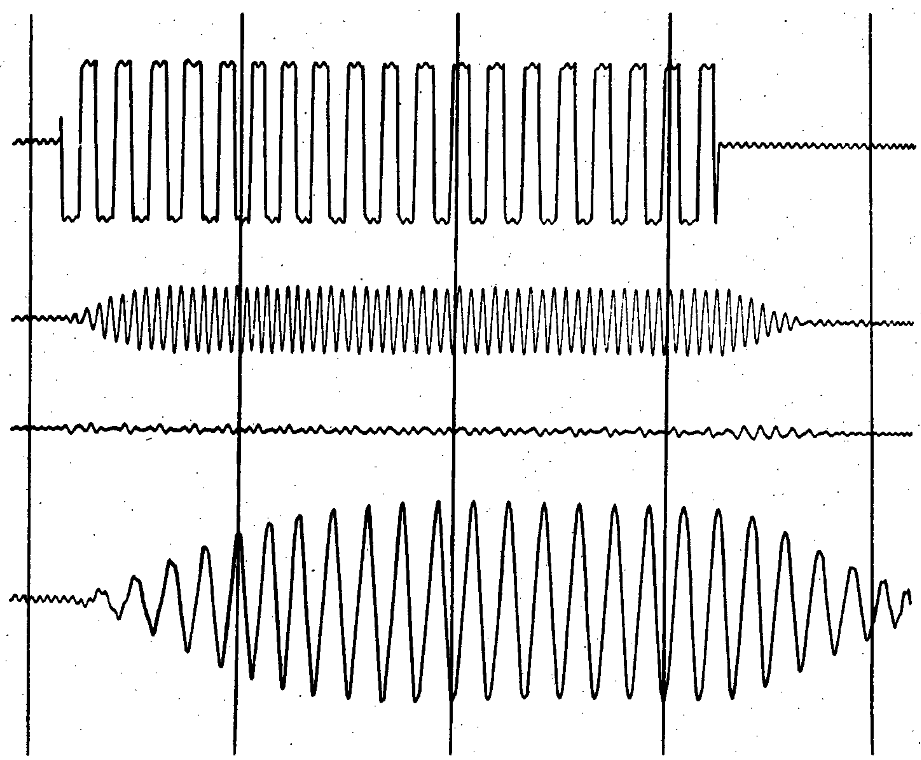
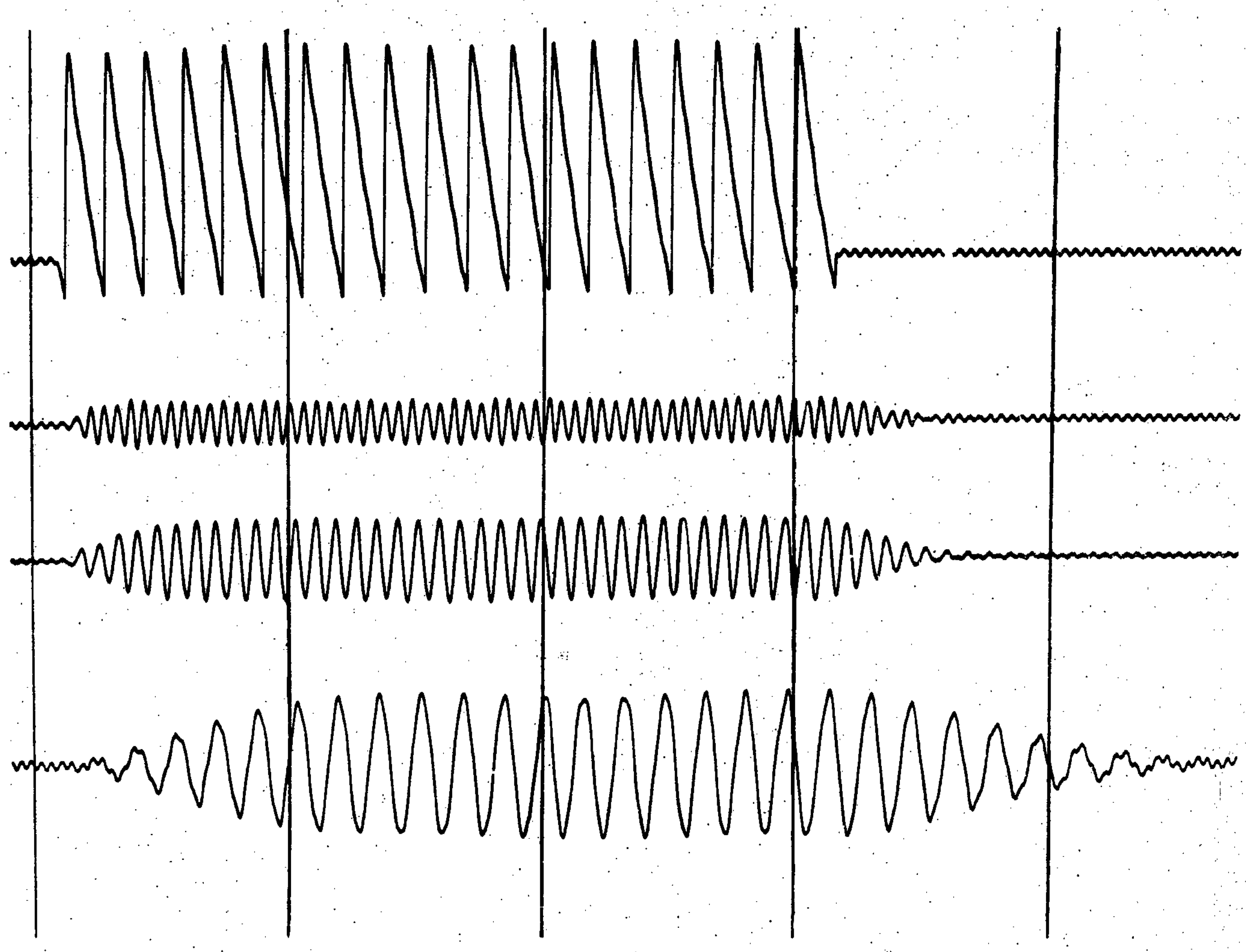


FIG. 14B. PULSED SQUARE WAVEFORM AND CHIEF FREQUENCY COMPONENTS



TIME SECS

FIG. 14C. PULSED SAWTOOTH WAVEFORM AND CHIEF FREQUENCY COMPONENTS

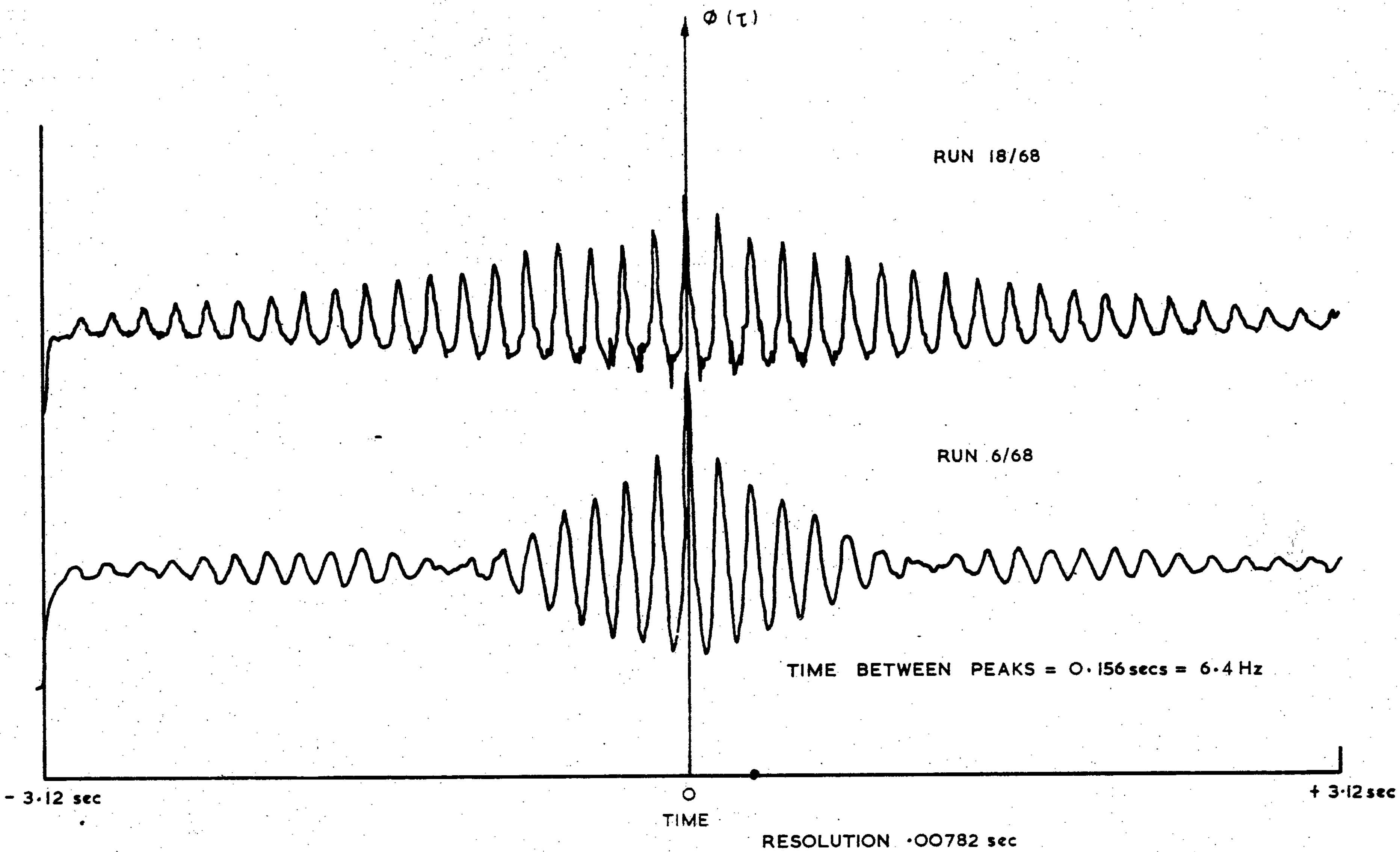


FIG. 15 AUTO-CORRELATION FUNCTION OF BIRDS 18/68 AND 6/68

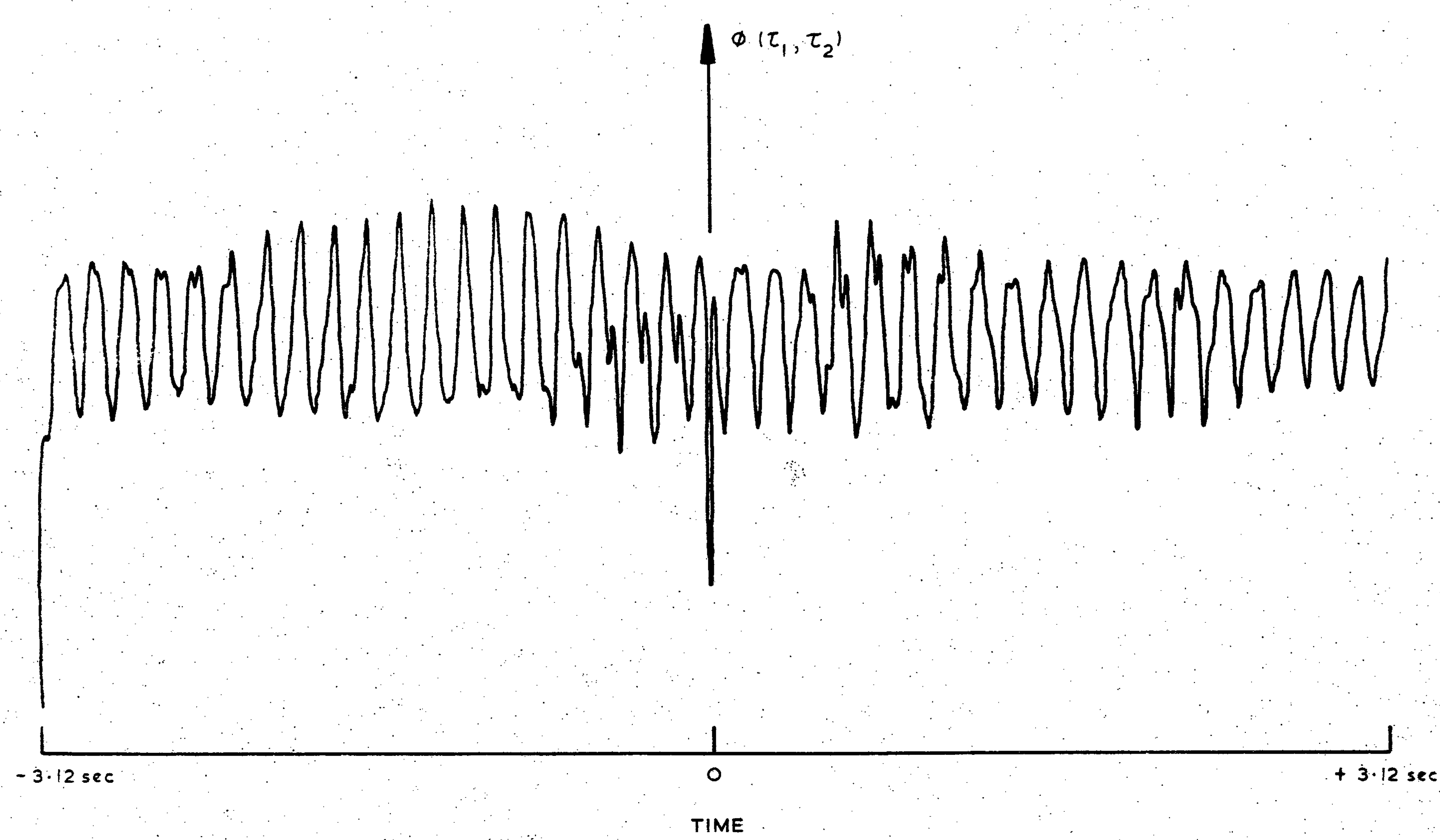


FIG. 16. CROSS CORRELATION FUNCTION OF BIRDS 18/68 AND 6/68

AD F 616 195

AS THIS PAPER IS THE WORK OF AN INDIVIDUAL MEMBER OF STAFF ANY OPINIONS AND CONCLUSIONS CONTAINED IN THIS PAPER ARE NOT NECESSARILY THE FINAL VIEWS OF THE CIVIL AVIATION AUTHORITY

F3

CONTENTS

1 INTRODUCTION

1.1 In the past reports containing data on bird strikes have been produced by different organisations, such as airlines, aviation authorities and ornithologists. The information has been presented in various forms, using different guidelines. These reports have seldom contained data on aircraft movements, such that the most useful form of comparison, strike rate, can be determined.

1.2 In order that a common basis for the analysis of bird strike data could be agreed, a Working Group of the Bird Strike Committee Europe was formed in 1972, led by the representative from the United Kingdom Civil Aviation Authority Airworthiness Division at Redhill. After consultation with other member countries sets of Analysis Tables with Explanatory Notes were circulated to all members of the BSCE, together with a request that each country produce an Analysis of their Bird Strikes. At the 1973 BSCE Meeting in Paris it was agreed that each country would provide a separate Analysis of their Civil, and of their Military bird strikes, commencing with 1972. At the 1974 BSCE Meeting in Frankfurt the Analysis Reports for the year 1972 were presented. The Civil Report was subsequently produced as CAA Airworthiness Division Technical Note No. 110.

1.3 This report contains a brief assessment of the data which has been provided by BSCE members on strikes to civil aircraft recorded during 1973. The strikes to military aircraft are reported separately.

1.4 Appendix 2 contains brief details of incidents involving engine damage, together with an analysis of engine strikes.

1.5 Appendix 3 contains brief details of strikes to Light Aircraft.

1.6 Appendix 4 lists reportable accidents caused by birds, world-wide during 1973.

2 SCOPE

For the following reasons, the detailed analysis only includes civil aircraft of over 5700 kg (12,500 lb) maximum weight (i.e.light aircraft are excluded):

(a) the airworthiness requirements relating to bird strikes are different for the smaller class of aeroplanes,

(b) much more is known about the reporting standard, and movement data of operators of transport types, and the movement data is more readily available than that from air taxi or private owner aircraft,

(c) the 5700 kg and less classification is, in general, a much slower aircraft with a different mode of operation, requiring less airspace, and a noticeably different strike rate would be expected.

3 COUNTRIES (see Table 1)

A total of seven European countries have provided information on 984 bird strik incidents. The data from Germany was not available using the comprehensive BSCE layout and could only be used in some of the Tables. It is hoped that more countries can provide data for future reports so that the whole of Europe can be covered. The overall strike rate is 3.52 per 10,000 movements (two movements per flight). This is slightly higher than the 1972 figure of 3.11, but this 1973 report does contain limited data from Germany which has a high number of strikes and a high strike rate. It is considered that although the change is statistically significant, such a small change in the rate is not significant as the data is very dependent upon reporting standards, annual variations etc, and note should ONLY be taken of large variations in the rate. In the 1972 report it was stated that "It could be expected that Denmark, Netherlands and the United Kingdom are maritime countries which would have similar rates; the fact that this report shows that they do not, may be a matter for investigation by specialists within each country." These features are again apparent in the 1973 report. The high strike rate reported by Germany is confirmed by the high number of strikes reported by the Royal Air Force based in Germany.

4 AIRCRAFT TYPES (see Table 2)

4.1 General

It may be that aircraft types which appear to be similar to humans, are not similar to birds, and that there are other factors, such as noise patterns, size, and use of lights, which affect the rate. The continued long term collection of statistics will provide fuller information. There are indications that the differing strike rates shown below for the various aeroplane types are statistically random.

4.2 Jet Aeroplanes

As in the previous report there appears to be little correlation, possibly for the reason suggested above, between aircraft of similar types the DC8 rate again being much higher than the Boeing 707. The 707 and DC8 are in wide use and operate on many identical routes, so a similar rate could be expected, although the rate for a type used by an operator who makes a high percentage of his movements at one particular airfield which has a bad bird problem, could affect the results. The wide-bodied aeroplanes, the Boeing 747 and Douglas DC10, for the year in question, do not show a particularly high strike rate; it remains to be seen whether this will continue.

4.3 Turboprop Aeroplanes

A similar situation exists in that the Herald rate is over 3 times that of the F27 Friendship, for aeroplanes that externally are almost identical. The highest rate is shown by the Vanguard/Merchantman. The average rate for all turboprop aeroplanes is slightly lower than that for Jets.

4.4 Piston Aeroplanes

The Convair 440 has the highest rate for piston engined aeroplanes, the average for all piston engined types being considerably less than that for Turboprops.

88

4.5 Helicopters

There were no strikes reported to the helicopters covered by this report.

4.6 Light Aircraft

Only four countries, Denmark, France, Sweden and the UK reported strikes to light aircraft. Appendix 3 gives the details of each incident, as the total is not large enough to warrant a full analysis. The total of strikes is surprisingly low since there are many more light aircraft in use than transport aircraft. It is quite likely that the low speed is relevant (see para 9).

5 AERODROMES (see Table 3 and 3A)

5.1 The aerodrome data is of particular importance as it shows where bird control measures need to be taken. This year several countries were able to provide data on Nationally registered Transport Aircraft movements at each aerodrome. The number of strikes would be expected to be high at, for example, Copenhagen, which is a particularly busy airport.

5.2 In Table 3 the rate for Amsterdam relates to the strikes to, and movements by, aircraft registered in the Netherlands. It can be seen that some of the smaller Scandinavian airports have a high strike rate, and that of the major airports Amsterdam, Basle, and Belfast appear to have a rate that is well above average.

5.3 The strikes reported by several countries, and thus for which no movement data is available, are shown in Table 3A. The number of strikes will be very dependent on the movements made by European operators, and the number of strikes can only be used as a guide.

6 BIRDS (see Table 4)

It can be seen that of the 349 reports where there was identification of the bird species, 53% were gulls, (1972 was 58%). The next largest total were Plover/Lapwings, with 12%. Only six strikes were known to involve birds of over 1.8 kg (4 lb) in weight.

7 MONTH OF THE YEAR (see Table 5)

As data on aircraft movement in each month is not available, except for the UK, it is not possible to show which months have the worst strike rate (in the United Kingdom July and October had the worst rate). The highest percentage of strikes were recorded by European Operators during July and October, irrespective of whether or not the UK data was included. It should be noted that in 1972 August and September were the worst months.

8 TIME OF DAY (see Table 5A)

The data provided for this year shows that 80% of strikes were during the day, when most of the aircraft movements take place and when the majority of birds are active. However, 12% (1972 - 20%) of the strikes were at

86

night when the number of aircraft movements are comparatively low. Unfortunately, in very few of these incidents at night were the birds identified, and further investigation of night time strikes should be made.

9 AIRSPEED (see Table 6)

In the previous report the slower speed divisions were 0-50 and 51-100 knots. It was felt that in the latter division it was probable that the majority of strikes were at the high speed end of the division, and in order to show this the divisions were changed to 0-80 and 81 to 100 knots.

Since only 3.7% of strikes occurred at speeds up to 80 kts, it could be concluded that at low speed the birds generally are successful in avoiding the aircraft. Between 80 and 100 kts a further 13.6% of strikes occurred which tends to confirm the above conclusion. Only a small proportion (3.1%) of the strikes occurred at high speed, mainly because the aircraft are above the altitude at which birds are common. These percentages may well be affected by the amount of time that the aircraft spends in each speed band. The percentages are very close to those in the 1972 Report.

10 ALTITUDE (see Table 6A)

Overall, 74% of the strikes were recorded as being between 0 and 200 ft, with 10% between 201 and 800 ft. However, 6·7% occurred at altitudes above 2500 ft, where, unfortunately, the bird species is seldom identified. The percentages are virtually identical to those of the 1972 Report.

11 FLIGHT STAGE (see Table 7)

The take-off accounted for a slightly higher percentage of strikes than the landing (35% as against 32%,) but 14% were recorded during the final approach. It should be noted that during the Climb, Cruise and Descent 16% of the strikes were recorded, the phases when speeds are high. The percentages are again very close to those of the 1972 Report.

12 PART OF AIRCRAFT STRUCK (see Table 8)

Since the 1972 Report the contents of the table have been revised to provide more information. The nose section excluding the radome received 22·7% of strikes, (the radome received 9·3%), and the engines received 18·4%. It should be noted that 1·6% of incidents affected more than one engine, 10 cases in all.

13 EFFECT OF STRIKE (see Table 9)

13.1 This information replaces the Table on Significance of Strike. It appears that this new table will provide a useful measure of the seriousness of the problem. One aeroplane was substantially damaged (Norwegian Dassault Jet Falcon, Norwich, December 1973), and has been included in this Table only, as Norway did not contribute any data for the rest of the Analysis.

13.2 One of the most serious aspects is that a total of 30 engines were changed, with a further 9 cases of repairs being necessary to the fan. Of the engine changes only six were on twin-engined aeroplanes, however there were also three cases of double engine change/fan repair to four-engined aeroplanes. Appendix 2 contains further data and analysis of engine strikes.

13.3 Only two windscreens were changed, although there were 98 strikes on windscreens. However 14 (excluding Germany) of the 57 radome strikes resulted in a radome change and it may be that the strength of radomes needs examination. There were 31 cases of skin denting, but only 13 cases of torn skin, broken landing lamp glass and deformed structure.

14 EFFECT versus AIRSPEED versus WEIGHT OF BIRD (see Table 9A)

This new Table as yet has not provided much information because only a small proportion of strikes cause damage, and for each of them the airspeed and bird species is necessary. It would be unwise as yet to draw conclusions from this Table; however continued collection of data will provide a better sample.

15 COST (see Table 10)

Four countries were able to provide information on 13 incidents the known total being at least 570,000 US Dollars. Of this a Swiss DC8 engine strike incident cost 405,000 US Dollars. The cost of jettisoning large quantities of fuel cannot now be ignored.

16 AIRCRAFT OPERATORS (see Table 11)

This Table provides a guide to the airline which either suffers the worst strike rate, or has the best reporting standard. It is probable that it is considerably affected by the airport(s) at which the airline has its main base. Of the major operators KLM and Lufthansa have the highest rate.

17 CONCLUSIONS

17.1 The overall rate for the seven European countries which have provided information is 3·52 per 10,000 movements. This is not significantly worse than the previous year. The Netherlands again has the highest rate, or possibly the best standard of reporting with a rate of 10·80.

17.2 There does not appear, on the available data, to be any correlation between the strike rate and the aeroplane type. The strike rate to wide-bodied aeroplanes is not significantly higher than that for other types. There are indications that the differing rates are statistically random.

17.3 Of the major airports Amsterdam, Basle and Belfast have markedly above average strike rates.

17.4 The gull was the bird species most frequently struck, being involved in 53% of the incidents. This is similar to the previous year. Only six incidents involved birds of greater than 1·8 kg (4lb).

17.5 The highest number of strikes occurred in October.

17.6 Although 80% of strikes occurred during daylight, 12% were at night, when the number of aircraft movements is low.

17.7 As 96·3% of strikes occurred above 80 knots, it appears that up to that speed there is a very good chance that birds can avoid aircraft.

17.8 A total of 84% of the strikes were recorded below 800 ft, however, 6·7% were above 2,500 ft, where speeds tend to be much higher.

17.9 The final approach and landing, as in the previous report, accounted for the same percentage of strikes as the take-off.

17.10 The nose section and radome were struck in 32% of the incidents, whilst engines accounted for 18·4%. There were 10 cases, (1·6%) where more than one engine was affected.

17.11 The major effect on the aeroplane is that one in four radome strikes necessitated a radome change. There were a total of 30 engine changes and 9 cases of fan repairs, approximately one in three of incidents involving engine changes or repairs. There were three cases of a double engine change/fan repair. Only two of these incidents were known to involve birds of greater than 1·8 kg (4lb).

17.12 The four countries which reported costs, sustained a total of at least 570,000 US dollars damage due to bird strikes.

17.13 It is only by collection and examination of statistics from several countries that a fuller understanding of the many aspects of the problem will be obtained.

18 PROPOSED ACTIONS

18.1 That those European countries which did not provide analyses using the BSCE layout should again be requested to provide the information. The countries concerned are Austria, Germany, Italy, Norway, Portugal and Spain.

18.2 That the Authorities responsible for airports with above average strike rates should be made aware and requested to investigate and take appropriate action.

18.3 The differing abilities of the various parts of the aircraft and engines to withstand bird strikes should be made known to those responsible for the airworthiness of aircraft, and to Operators.

APPENDIX 1

BIRD STRIKE ANALYSIS

EUROPEAN OPERATORS 1973

CIVIL AIRCRAFT OVER 5700kg (12,500lb) MAXIMUM WEIGHT

Notes: 0.1 The following are NOT included in this Analysis:

(a) aircraft of maximum weight 5700kg (12,500lb) and under;

(b) all military type and operated aircraft.

0.2 Strikes to aircraft in (a) above are tabulated in Appendix 2

0.3 All Tables are for strikes reported world-wide, except for Table 5 which is for Europe only.

0.4 The Total columns of many of the Tables are different, as some countries have not been able to provide full information for every Table.

TABLE 1 - COUNTRY

Country	Number of Incidents	Number of Movements	Rate per 10,000 Movements
Denmark	42	218,440	1·92
France*	54	490,560	1·10
Germany+	286	347,190†	8·25
Netherlands**	154	142,100	10·80
Sweden	75	427,590†	1·75
Switzerland++	55	179,820	3·06
United Kingdom	318	991,740	3·20
TOTAL	984	2,797,440	3·52

Notes: 1.1 There are two movements per flight.

*1.2 Data from France does not include piston engined aircraft.

+1.3 Data used only in Tables 1, 2, 4 and 9.

†1.4 Movement data is from ICAO sources.

**1.5 From KLM airline only.

++1.6 Data from Switzerland only includes jet aeroplanes.

TABLE 2 - AIRCRAFT TYPE

Type	Aircraft	No. of Countries Reporting.	No. of Strikes	No. of Movements	Strikes per 10000 Movements
JET					
4 engined	Douglas DC8	5	97	143,970	6·74
	Boeing 747	7	34	66,490	5·11
	Boeing 707/720	4	90	201,870	4·46
	BAC VC 10	1	20	57,970	3·46
	Convair 990 Coronado	1	7	24,390	2·87
	H.S. Comet 4	1	1	27,440	0·36
3 engined	Boeing 727	3	144	203,510	7·08
	Douglas DC 10	5	6	16,510	3·63
	H.S. Trident	1	58	183,700	3·16
	Lockheed 1011 Tristar	1	0	3,350	0
2 engined	Fokker F28 Fellowship	2	14	12,440	11·25
	Boeing 737	2	80	183,880	4·35
	Douglas DC9	4	132	419,590	3·15
	BAC 1-11	2	48	242,560	1·98
	Sud 210 Caravelle	3	31	304,730	1·02
	H.S. 125	1	1	11,210	0·90
TURBOPROP					
4 engined	BAC Vanguard/Merchantman	1	17	35,500	4·80
	Canadair CL 44	1	3	6,290	4·77*
	BAC Viscount	2	77	183,070	4·21
	BAC Britannia	1	0	7,040	0
	H.S. Argosy	1	0	1,960	0
2 engined	Short Skyvan	1	3	6,430	4·66*
	H.P. Herald	1	12	39,680	3·02
	Nord 262	3	12	44,400	2·70
	H.S. 748	1	6	29,890	2·08
	DHC-6 Twin Otter	2	2	21,510	0·93
	Fokker F27 Friendship	4	8	89,020	0·90
PISTON					
	Convair 440	2	31	149,310	2·08
	DC3 Dakota	1	1	15,730	0·64
	ATL Carvair	1	0	20,520	0
	H.S. Heron	1	0	5,160	0
UNKNOWN		-	49	-	-
HELICOPTERS		-	0	38,320	0

TABLE 2A - SUMMARY OF AIRCRAFT TYPES

Jet	763	2,103,610	3·63
Turboprop	140	464,790	3·01
Piston	32	190,720	1·68
Helicopter (Hours)	0	38,320	0
Unknown	49	-	-
TOTAL- Including those with NIL Strikes	984	2,797,440	3·52

Notes: 2.1 There are two movements per flight.

*2.2 Rates for types with less than 10,000 movements are included in the Table, but are subject to some error.

22

AIRFIELD	[illegible] TO NATIONAL REGISTERED AIRCRAFT	MOVEMENTS OF NATIONAL REGISTERED AIRCRAFT	STRIKES PER 10,000 MOVEMENTS
DOMESTIC - Strikes reported by the airlines of the individual country, related to the movements by those airlines.			
Denmark			
Copenhagen, Kastrup	16	80,200	2·00
Esbjerg	2	2,800	7·15*
Odense, Beldringe	3	3,300	9·10*
France			
Toulouse	3	18,610	1·60
Paris, Le Bourget	3	56,754	0·52
Marseilles	2	40,112	0·50
Paris, Orly	5	203,258	0·24
Nice	4	39,378	0·10
Netherlands			
Amsterdam	45	45,840	9·80
Sweden			
Visby	7	11,000	6·35
Göteborg	4	31,800	1·30
Malmö	2	18,400	1·10
Stockholm, Bromma	4	48,200	0·80
Sundsvall	1	13,200	0·80
Halmstad	6	4,000	15·0 *
Angelholm	4	3,400	11·8 *
Kristianstad	2	2,200	9·1 *
Kalmar	2	5,200	3·8 *
Karlstad	2	4,600	4·5 *
Borlänge	2	5,200	3·9 *
Norrköping	2	7,800	2·6 *
Jönköping	2	8,600	2·3 *
Luleå	2	8,800	2·3 *
Switzerland			
Basle	9	10,510	8·56
Zurich	21	51,550	4·07
Geneva	5	31,820	1·57
U.K.			
Ronaldsway, Isle of Man	24	9,320	25·8
Glamorgan/Rhoose	10	5,700	17·5 *
Wick	4	2,600	15·4 *
Blackpool	4	3,100	12·9 *
Belfast	21	20,700	10·1
Glasgow	26	32,280	8·0
Birmingham	10	15,570	6·4
Liverpool	5	10,570	4·7
Prestwick	13	30,200	4·3
Teesside	3	7,400	4·0 *
East Midlands	4	12,200	3·3
Newcastle	3	9,500	3·2 *
London, Heathrow	43	147,450	2·9
Edinburgh	8	28,600	2·8
Luton	4	34,100	1·2
Manchester	3	38,400	0·8
London, Gatwick	5	71,700	0·7

See next page for footnote to this Table.

TABLE 3A

FOREIGN - Alphabetical list of airfields where more than one strike has been reported by European countries, and thus the movements are not known.

Abidjan (Ivory Coast)	3	London, Heathrow (UK)	7
Alicante (Spain)	2	Madrid (Spain)	2
Bangkok (Thailand)	2	Malaga (Spain)	2
Bangui (C. African Rep.)	5	Montago Bay (Jamaica)	2
Beirut (Lebanon)	2	Montpellier (France)	3
Berlin (W. Germany)	6	Montreal (Canada)	2
Bombay (India)	3	Munich (W. Germany)	3
Brussels (Belgium)	6	New York, JFK (US)	4
Cologne/Bonn (W. Germany)	2	Paris, Orly (France)	4
Copenhagen (Denmark)	15	Paris, Le Bourget (France)	7
Dar-es-Salaam (Tanzania)	2	Oslo (Norway)	3
Delhi (India)	2	Rome, Fuimicino (Italy)	5
Frankfurt (W. Germany)	2	Singapore (Malaysia)	2
Geneva (Switzerland)	3	Stockholm, Arlanda (Sweden)	3
Guernsey (Channel Is.)	8	Tehran (Iran)	2
Hanover (W. Germany)	2	Tunis (Tunisia)	2
Istanbul (Turkey)	6	Venice (Italy)	2
Jersey (Channel Is.)	5	Vienna (Austria)	2
Kano (Nigeria)	2	Zurich (Switzerland)	3

Other airfields with single strikes	115
En-route	18
Unknown	71
TOTAL	698

Notes: 3.1 By reason of geographic location certain islands may have been regarded as 'Foreign'.

*3.2 Rates for airfields with less than 10,000 movements are included in the table, but are subject to some error.

3.3 Some airfields appear twice, firstly where the strikes are related to movements, and secondly where the strikes are reported by several different countries, and cannot be related to movements.

29

TABLE 4 - BIRD SPECIES

Common Name	Scientific Name	Approx Weight	Cat	Number of Strikes	% Based on 349
Black Headed Gull	Larus ridibundus	300g	B	7	2·0
Herring Gull	Larus argentatus	1·1Kg	B	4	1·1
Mediterranean Gull	Larus melanocephalus	300g	B	9	2·6
"Gulls"	Larus spec.	300g-1·8Kg	B	166	
TOTAL GULLS	-	-		186	53·3
Plover/Lapwing	Vanellus vanellus	200g	B	43	12·3
Swift/Swallow/Martin	-	14g-40g	A	28	8·0
Pigeon	Columba spec.	400g-500g	B	24	6·9
Kestrel	Falco tinnunculus	200g-800g	B	7	2·0
Starling	Sturnus vulgaris	85g	A	7	2·0
Oyster Catcher	Haematopus ostralegus	550g	B	6	1·7
Crow/Rook	-	400g-550g	B	6	1·7
Owl	Tyto spec.	170g-380g	B	4	1·1
Common Buzzard	Buteo buteo	800g-2Kg	B	4	1·1
Sparrow	-	18g-40g	A	3	0·9
Pheasant	Phasianus colchicus	1·2Kg	B	3	0·9
Vulture/Large Hawk	-	-	C	3	0·9
Blackbird	Turdus merula	100g	A	2	-
Skylark	Alauda arvensis	40g	A	2	-
Duck	Anas spec.	-	B	2	-
Sparrow Hawk	Accipter nisus	200g	B	2	-
Hawk/Buzzard	-	-	B	2	-
Mallard	Anas platyrhynchos	900g	B	1	-
Grey Heron	Ardea cinerea	1·8Kg	B	1	-
Magpie	Pica pica	220g	B	1	-
Tern	Sterna spec.	40-240g	B	1	-
Partridge	Perdix perdix	300g-400g	B	1	-
Curlew	Numenius arquata	800g	B	1	-
Hooded Crow	Corrus corone	550g	B	1	-
Red Kite	Milvus milvus	700g-1Kg	B	1	-
Black Kite	Milvus migrans	1Kg	B	1	-
Maribou Stork	Leptoptilos spec.	up to 4 Kg	D	1	-
Griffon Vulture	Gyps fulvus	5·4 Kg	C	1	-
Black Grouse	Lyrurus tetrix	1·1Kg	B	1	-
Redshank	Tringa totanus	130g	B	1	-
Swan	Cygnus spec.	up to 10Kg	D	1	-
Unknown	-	-	-	349	-
TOTAL	-	-	-	698	-

Notes: 4.1 Bird weights and Latin names are based on Canadian Field Note No. 51 by G. Kaiser, unless there is positive evidence to the contrary the AVERAGE weight is assumed.

4.2 The Bird Categories based on current Civil Airworthiness requirements are:

Cat.A below 110g ($\frac{1}{4}$ lb)
Cat.B 110g to 1·81Kg ($\frac{1}{4}$ lb to 4 lb)
Cat.C over 1·81 Kg to 3·63 Kg (4lb to 8lb)
Cat.D over 3·63 Kg (8lb)

4.3 These birds not positively identified are tabled as Unknown.

4.4 Large (Cat. C or D) birds are often not positively identified, the Category these are assumed to be has been stated.

4.5 Percentages are based on known totals.

95

TABLE 5 MONTH OF YEAR

MONTH	WEIGHT* UNKNOWN	CAT A and CAT B	CAT C and D	TOTAL*	% BASED ON 506
January	6	9	0	15	3·0
February	5	10	1	16	3·1
March	19	10	1	30	5·9
April	17	3	0	20	3·9
May	27	17	0	44	8·7
June	24	16	0	40	7·9
July	33	41	0	74	14·6
August	32	28	0	60	11·8
September	25	36	0	61	12·0
October	49	39	0	88	17·4
November	22	15	0	37	6·1
December	3	18	0	21	4·1
Month Unknown	1	0	0	1	-
TOTAL	263	242	2	507	

TABLE 5A TIME OF DAY

TIME	WEIGHT UNKNOWN	CAT A and CAT B	CAT C & D	TOTAL	% BASED ON 293
Dawn	2	10	0	12	4·1
Day	53	181	0	234	80·0
Dusk	3	8	0	11	3·8
Night	16	20	0	36	12·0
Unknown	2	8	2	12	-
TOTAL	76	227	2	305	

Notes:-

5.1 Restricted to strikes reported in Europe.

*5.2 Includes data from Germany, but does not include Netherlands.

5.3 In absence of Movement data, percentages are used and are thus dependent on the number of aircraft movements each month.

5.4 Percentages are based on known totals.

TABLE 6 AIRSPEED

AIRSPEED (kts IAS)	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON ..353...
0 - 80	5	2	6	0	13	3•7
81 - 100	10	3	35	0	48	13•6
101 - 150	69	31	118	3	221	62•5
151 - 200	26	8	13	1	48	13•6
201 - 250	10	1	2	0	13	3•7
Over 250	9	0	2	0	11	3•1
Airspeed Unknown	196	10	136	2	345	-
TOTAL	325	55	312	6	698	-

TABLE 6A ALTITUDE

ALTITUDE (ft)	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON ..475...
0 - 200	97	32	220	3	352	74•1
201 - 800	27	10	10	2	49	10•3
801 - 2500	24	5	13	0	42	8•8
Over 2500	22	1	9	0	32	6•7
Altitude Unknown	155	7	60	1	223	-
TOTAL	325	55	312	6	698	-

Notes:-

6.1 When the Altitude is not specifically stated, but the Flight Stage is quoted as take-off or landing the 0 to 200 ft division is assumed.

6.2 Birds found dead on the runway are included in the 0 to 200 ft division.

6.3 The percentages are based on the known totals.

TABLE 7 FLIGHT STAGE

STAGE	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON ..548...
Taxying	2	0	2	0	4	0·7
Take-off	67	14	112	0	193	35·2
Initial climb	4	0	2	0	6	1·1
Climb	36	11	14	1	62	11·3
Cruise	3	0	2	0	5	0·9
Holding	0	0	0	0	0	0
Descent	17	1	5	0	23	4·2
Final Approach	40	9	27	2	78	14·2
Landing	51	15	105	3	174	31·7
Touch & Go/Overshoot	0	0	3	0	3	0·5
Unknown	105	5	40	0	150	-
TOTAL	325	55	312	6	698	-

Notes:-

7.1 It is not possible to provide a precise definition of these stages as the altitudes vary with aircraft type, and particular operation.

7.2 Birds found dead on the runway are divided equally between take-off and landing.

7.3 The percentage is based on the total where the stage is known.

TABLE 8 PART OF AIRCRAFT STRUCK

PART	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON 613
Fuselage, excl. Nose etc	33	8	34	0	75	12·2
Nose, excluding radome and windscreen	75	13	51	0	139	22·7
Radome	30	5	22	0	57	9·3
Windscreen	45	14	39	0	98	16·0
Engine:-						
1 engine struck	48	5	47	3	103	16·8
2 out of 3 struck	0	0	0	0	0	0
2 or more of 4 struck	4	0	6	0	10	1·6
all engines struck	0	0	1*	0	1*	0·2
Wing	43	3	54	3	103	16·8
Landing Gear	5	1	14	0	20	3·2
Empennage	6	0	1	0	7	1·1
Part Unknown	61	9	93	1	164	-
TOTAL	350	58	362	7	777	-

Notes:-

8.1 The Totals in Table 8 are higher than the others, as one bird can strike several parts.

8.2 The percentages are based on incidents where the part struck is known.

8.3 Where both landing gears, or both wings are struck, two incidents are recorded.

TABLE 9 EFFECT OF STRIKE*

EFFECT	WEIGHT UNKNOWN	CAT A	CAT B	CAT C	CAT D	TOTAL	% BASED ON 548
Loss of life/aircraft	0	0	(1)†	0	0	(1)†	-
Flight Crew Injured	0	0	(3)†	0	0	(3)†	-
Engines Changed on:-							
2 engined aircraft	2(3)	0	1	0	0	3(3)	0.5
others	14(3)	0	6	1	0	21(3)	3.8
Windscreen changed	0	0	2	0	0	2	0.3
Radome changed	8(3)	0	6(1)	0	0(1)	14(5)	2.5
Deformed Structure	2	0	6	0	0	8	1.5
Skin Torn	2(5)	0	2(1)	1	0(1)	5(7)	0.9
Skin dented	19(12)	0	12	0	0	31(12)	5.7
Propeller/Rotor/Fan damaged	4(1)	1	0(2)	0	1(1)	6(4)	1.1
Aircraft system lost	0(2)	0	2	0	0(1)	2(3)	0.3
Nil damage	237(252)	47	168	3	0	455(252)	83.0
Unknown	44	7	109	1	0	161	-
TOTAL	332(281)	55	315(4)	6	1(4)	709(289)	-

TABLE 9A EFFECT - AIRSPEED - WEIGHT OF BIRD

EFFECT	AIRSPEED	0-80		81-100		101-150		151-200		201-250		over 250	
	WEIGHT	A&B	C&D	A&B	C&D	A&B	C&D	A&B	C&D	A&B	C&D	A&B	C&D
Loss of Life/Aircraft													
Flight Crew Injured													
Engines Changed on:-													
2 engined aircraft													
other aircraft						3			1				
Windscreen Changed								1					
Radome Changed						1	2			1		1	
Deformed Structure						1							
Skin Torn													
Skin Dented				2		5		1					
Propeller/Rotor/Fan Damage									1				
Nil Damage													
Unknown													
TOTAL				2		10	2	2	2	1		1	

Notes:-

9.1 The Totals in Table 9 are higher than the others, as one bird can strike several parts.

*9.2 The figures in brackets refer to Germany.

†9.3 Relates to an accident to a Norwegian registered aircraft, used in Table 9 only

9.4 Aircraft system lost includes for example electrical, hydraulic, brake, air conditioning, de-icing.

9.5 If for example skin is torn in two places, or both windscreens are broken two incidents are recorded.

9.6 The TOTAL of Table 9A does not agree with other tables, as those incidents where the bird weight or airspeed are unknown have been omitted. /OC

TABLE 10 **COST**

TYPE OF STRIKE	NUMBER	TOTAL COST (US DOLLARS)
Where cost is known	13	570,000
AVERAGE COST		44,000

Notes:-

10.1 The cost includes the following:-

(a) Engineering rectification costs.

(b) Loss of revenue.

(c) Incidental costs, i.e. diverted aircraft, passenger accommodation etc.

10.2 The engineering rectification cost on ENGINES should be offset by the hours remaining before overhaul.

TABLE 11 AIRCRAFT OPERATOR REPORTING STRIKES

OPERATOR	NUMBER OF STRIKES	NUMBER OF MOVEMENTS	STRIKES PER 10,000 MOVEMENTS
DENMARK			
Cimber Air	6	16,980	3·53
Conair	1	7,660	1·31
Maersk Air	4	20,740	1·93
SAS	17	89,470	1·90
Sterling Airways	12	62,510	1·92
FRANCE			
Air France	18	279,652	0·64
Air Inter	15	130,032	1·15
UTA	19	38,480	4·93
Rousseau	1	24,096	0·41
Air Alpes	1	N/A	-
GERMANY			
Lufthansa	286	347,190	8·25
NETHERLANDS			
KLM	154	142,100	10·80
SWEDEN			
SAS	28	363,670	0·77
Linjeflyg	36	59,920	6·01
Transair	4	4,000	10·00
Crownair	1	N/A	-
SWITZERLAND			
Swissair	55	179,824	3·06
UK			
Cambrian	26	51,010	5·1
British Airways (OD)/BOAC	44	107,790	4·1
British Airways (ED)/BEA	120	311,400	3·9
Tradewinds	1	2,980	3·4
British Midland	11	38,300	2·9
Northeast Airlines	7	25,190	2·80
British Island Airways	12	43,360	2·8
British Airways Regional Div	15	58,410	2·6
Intra	1	4,930	2·0
Monarch	2	10,640	1·9
British Caledonian	17	97,690	1·8
Britannia	5	36,000	1·4
Court Line	4	29,400	1·4
Dan Air/Dan Air Skyways	9	70,930	1·3
McAlpine	1	9,040	1·1
British Air Ferries	1	22,760	0·4
Loganair	1	1,620	-
Unknown		-	-
TOTAL	984		

Notes:-

11.1 **The Movements of operators who did not report any strikes are not included.**

11.2 **Leased** aircraft are included against the operator.

BIRD STRIKES TO ENGINES

1 INTRODUCTION

1.1 During the examination of the information supplied by BSCE members it was decided to attempt a special analysis of the engine strikes recorded during 1973. In order to complete this work it was also necessary to have available the information sent to ICAO. This restricted the analysis to the following countries, Germany, France, Netherlands and UK.

1.2 As the data on aeroplane movements was available it was decided to change this into engine flights, to take due account of 2, 3 and 4 engined aeroplanes.

1.3 The results should be treated with caution as the sample size is in some cases quite small, and the quality depends on the reporting standards of the four countries.

2 DISCUSSION OF RESULTS

2.1 From Table A it can be seen that the percentage of strikes which cause damage varies considerably, and is not consistent from one aeroplane to another eg. DC8 and B707. However, it appears that the JT8D whether in the B737, B727 or DC9 suffers very little damage, especially in comparison with the JT9D from the B747.

2.2 The above is confirmed by Table B which shows that the damage rate per million engine flights is very much higher for the JT9D and JT3D than for the other engines.

2.3 From Table C it can be seen that when considering all strikes a wing mounted engine is four times more likely to be struck than an aft-mounted engine, and when considering damaging strikes it is eight times more vulnerable. The true ratio probably lies between the two figures since it is quite likely that some of the non-damaging strikes are not noticed. It is clear that the wing and fuselage are acting as an efficient bird filter. The Spey and to a lesser extent JT8D aft-mounted rates will be affected by the very favourable centre engine installation of the Trident and B727.

2.4 It can be seen from Table C that the rates for all strikes for engines of a similar type of installation are dependent upon the intake area. This is confirmed by the rate for damaging strikes, since the latter are certain to be noticed. However, it appears that the number of strikes is not directly proportioned to the intake area.

3 CONCLUSION

3.1 It will be necessary to obtain further data, preferably from another year, in order that the trends in the above discussion of results can be confirmed.

3.2 It will be necessary to obtain more information about the B707 and DC8 in order to determine the exact type of engine involved.

BSCE/10-WP/
Appendix 2

Table A

Aircraft Type	Engine Type	Engine Location ✝	Engine Flights	Number of Engine Strikes	Strike Rate per Million Engine Flights	Number of Engines Changed/ Repaired	% of Strikes Which Cause Damage
HS Comet 4	RR Avon	-	55,000	2	36 x	2	100 x
BAC 1-11	RR Spey	A	242,400	4	16	2	50 x
Boeing 707	P&W JT3D/JT4	W	312,000	26*	83	12	46
Boeing 747	P&W JT9D	W	118,000	22	186	9	41
SUD Caravelle	RR Avon	A	162,000	4	25 x	1	25 x
Boeing 707	RR Conway	W	67,400	8*	119	2	25 x
Douglas DC8	P&W JT3D/JT4	W	158,000	33	209	7	21
Boeing 727	P&W JT8D	A	305,400	16	52	3	19
Boeing 737	P&W JT8D	W	183,900	21	114	4	19
Douglas DC9	P&W JT8D	A	73,200	3	41 x	0	0 x
SUD Caravelle	P&W JT8D	A	18,000	0	0 x	0	0 x
BAC VC10	RR Conway	A	116,000	5	43	0	0 x
HS Trident	RR Spey	A	276,000	2	7 x	0	0 x
Fokker F 28	RR Spey	A	2,600	0	0 x	0	0 x
Douglas DC10**	GE CF6	-	19,050	1	52 x	0	0 x
TOTAL			2,108,950	147	69.5	42	-

Notes:

* A.1 Approximate Figure as full data not available

A.2 Data from France, Germany, Netherlands and UK.

✝ A.3 A = Aft mounted, W = Wing mounted

x A.4 Where there is a small sample size the results should be treated with caution.

** A.5 Very small total, has two wing mounted and one aft engine.

2-2

Table B

Engine Type	Number of Engine Flights	Number of Engines Changed/ Repaired	Damage Rate per Million Engine Flights
P & W JT9D	118,000	9	76
P & W JT3D/JT4	470,000	19*	40
RR Avon +	217,000	3	14
RR Conway	163,000	2	12
P & W JT8D	580,000	7	12
RR Spey	521,000	2	4
GE CF6	19,000 **	0	0

Notes: * B.1 Approx Figure as full data not available

B.2 Data From France, Germany, Netherlands and UK.

+ B.3 Includes Comet

** B.4 Very small total, has two wing mounted and one aft engine.

Table C

Engine Type	ALL STRIKES								STRIKES CAUSING DAMAGE					
	ENGINE AREA		AFT MOUNTED			WING MOUNTED			AFT MOUNTED			WING MOUNTED		
	Square Metres	Square Inches	No.	Engine Flights	Rate x	No.	Engine Flights	Rate x	No.	Engine Flights	Rate x	No.	Engine Flights	Rate x
RR Conway	1.03	1600	5	116,000	43	8*	67,000	120	0	116,000	0	2*	67,000	30.0
RR Spey	0.55	850	6	521,000	11.5	-	-	-	2	521,000	3.8	-	-	-
P&W JT3D/JT4	0.80/ 1.29	1250/ 2000	-	-	- -	59*	470,000	125	-	-	-	19*	470,000	40.5
P&W JT8D	0.80	1250	19	397,000	48	21	183,900	114	3	396,600	7.6	4	183,900	22.0
P&W JT9D	4.16	6450	-	-	-	22	118,000	186	-	-	-	9	118,000	76.0
TOTAL			30	1,034,000	29	110	838,900	131	5	1,034,000	4.8	34	838,900	40.5

Notes

* C.1 Approximate figures as full data not available

C.2 Data from France, Germany, Netherlands and UK

C.3 Where there is a small number of strikes, or movements the results should be treated with caution.

C.4 Engine area is front flange area.

x C.5 The rate is per million engine flights

136

SERIOUS BIRD STRIKES TO ENGINES, 1973

1 SUMMARY OF INCIDENTS

BELGIUM

Dassault Jet Falcon *	At Northolt during landing run No.1 engine ingested lapwing. engine changed.
Lear 24 *	On take-off from Belfast, struck plover flock at 50 ft, made emergency landing after No.1 engine failed.

FRANCE

Caravelle	Struck unknown birds on approach to Montpellier, No.2 engine changed.
B.707	Struck gulls at 2,000 ft during take off from Marselles, engine shut down, and later changed.
B.747	Struck birds at 140 kts at ground level on take off from Paris Orly, engine vibration, engine changed.
DC 8-55	Struck birds at 600 ft on climb from Le Bourget, engine changed.
DC8	Struck gulls on take-off from Cherbourg, <u>two</u> engines changed.
DC8-63	Struck birds at ground level on take-off from Nice, 3 engined Ferry Dakar to Paris, engine changed.
B.707	engine change after striking birds on landing at Johannesburg
B.747	engine No.4 damaged on take-off from Montreal.
DC8-53	Struck pipurangs at ground level on landing at Bangui, ferry flight on 3 engines, engine changed.
DC8- 55F	Struck large bird at 500 ft on take-off from Ouagadougou, engine shutdown due to surging, 3 engine ferry, engine changed.

GERMANY

B727	Struck gulls on Take-off from Rhodes, No.1 engine rotor blades replaced.
B727	Struck birds on take-off from Rhodes, No.1 engine changed.

B.737	Struck birds on take-off from Milan (Linate) No.1 engine changed.
B.737	Struck birds on approach to Munich, No.2 engine changed.
B.707 - 330	Struck birds at Frankfurt, No.1 engine changed.
B.747	Struck birds at Hamburg, rotor blades changed on No.3 engine.
B.707-330	Struck vulture at 300 ft on take-off from Dakar, damage to No.1 engine and radome.
B.707-330	Struck gull at 150 ft on take-off from Istanbul, damage to No.3 engine.
B.737	No.1 engine changed due to bird strike.
B.707-330	Struck birds at 750 ft at 130 kts on approach to Chicago, damage to No.1 engine Fan.

Note: LBA Report III 3 - 957.12.2 contains further strikes, resulting in damage, but details are not given.

NETHERLANDS

B.747B	Struck flock of unknown birds at 50ft on take-off, from Amsterdam loud bang heard and No.2 JPT rising fast, shutdown and returned after jetisonning 35000 kgs fuel.
B.747	Struck birds at New York (JFK), No.1 engine replaced.
DC8 33/55	Struck flock on take-off from Istanbul. Engine No.3 stalled and No.4 oil temp increased, diverted to Vienna , Engine 3 showed 26 blades to be damaged, No.4 oil cooler clogged by bird remains, 3 engine ferry.
B.747B	Struck flock at 100 ft on take off from Amsterdam, Engine 4 N1 dropped to 40% with rumbling, shutdown and returned after jettisoning 63,000 kgs of fuel.
B747B	Engine No. 2 found to have damaged fan blades, 4 blades replaced, bird remains removed.
B747B	On take-off from Amsterdam No. 1 engine ingested gulls, several fan blades bent.

SWEDEN

DC9	Abandoned take-off after striking gulls at V_1 - 20 kts, drop in No.1 EPR and N_1.

SWITZERLAND

DC8	Struck Maribou stork at 1,000 ft on approach to Bombay, No.1engine repair cost 987,000 Swiss Francs.

UNITED KINGDOM

Boeing 707 (P & W)	Struck large kite at 800 ft on landing at Kano, No.1engine compressor damaged.
BAC 1-11	Struck gulls at 50 ft on take-off from Kinloss, bird bounced off radome and into No.2 engine, damage to all stages of compressor, returned for engine change.
B.747	No.1 engine injested bird on take-off from Delhi, 35,000 kg fuel jettisoned, directed to Bombay, engine changed.
B.707 (P & W)	No.1 engine changed, strikes on approach to St. Lucia.
BAC 1-11	No.1 engine damaged by night-time strike whilst in cruise en-route to Luton.
B. 707 - 336C	During take-off run from Heathrow, No.1,2, & 4 engine injested gulls, No.4 surged badly, & ATC reported flames, reduced to idle & shutdown. No.2 surged initially and later stabilized at reduced power. Returned to Heathrow. No.4 engine changed due to severe compressor damage, slight No.1 engine damage.
B.707 (RR)	No.4 engine shutdown during night take-off from Prestwick, changed due to severe compressor damage.
Westland Commando* Helicopter	During night training at 70 ft, 90 kts, flew into flock of lapwings, emergency landing on the airfield, as high pitched whine from No.1 engine. No.1 engine had IGV and compressor damage.
Comet 4B	During preflight checks at Alicante (after flight from Glasgow) No.1 engine IGV & first stage compressor found damaged, engine free and run down time OK. No.2 engine had IGV and first and second stage compressor damage and case fouling. 3 engine ferry to Gatwick, No.1 & 2 engines changed.

NORWAY

Dassault * Jet Falcon	During take-off from Norwich aircraft passed through several flocks of gulls at 300 ft, both engines failed, one due to the fan being split in half, the other due to severe core engine damage. Aircraft crash landed in field 1 km beyond end of runway. Minor injuries to crew, six passengers unhurt. Aircraft written off due to fuselage buckling and loss of undercarriage.

*Incidents not included in the statistics used for this Report.

110

STRIKES TO EUROPEAN REGISTERED AIRCRAFT OF 5700 kg (12,500 lb) AND UNDER

	AIRCRAFT	DATE	TIME	LOCATION	ALTITUDE (ft)	IAS (kts)	PHASE	BIRD	NUMBER	PART STRUCK	DAMAGE
Denmark											
1	Cessna F172K	26.3.73	08.30	Copenhagen	15	70	Take-off	Gull	Single	Wing	Minor Dent
2	PA23-250	4.5.73	20.00	Billund	6000	170	Cruise	-	Single	Landing light damaged	
3	PA28-140	16.7.73	day	Roskilde	400	80	Climb	-	Single	Windscreen damaged	
4	PA22-108	11.9.73	18.50		1500	78	Cruise	-	Flock	Wing	Minor Dent in L/
5	Cessna 421B	13.9.73	19.20	Roskilde	5	85	Landing	Owl	Single	Engine	Nil
6	PA28-180	8.11.73	09.40	Fredericia	0	52	Take-off	Partridge	Pair	Windscreen	Nil
France											
1	Beech 99	25.1.73	07.20	La Rochelle	0	100	Take-off	Large Gull	-	Engine, Wing	No damage, 16 birds killed.
2	Beech 99	1.6.73	05.33	Chambéry	0	80	Take-off	Crow	-	Engine	Engine cowling replaced.
3	Jodel Club	17.6.73	13.20	Lyons	1000	110	Cruise	Starling	-	Wing	Dented Skin
4	MS880	26.12.73	14.30	Lyons	10	75	Landing	Falcon	-	Wing	Dented Skin
5	(Glider	24.5.73	15.30	Sisteron	-	-	-	Bird of Prey	-	Fuselage	Dented Skin)
Sweden											
1	Beech 55	27.3.73	13.50	Orebro	50	80	Approach	Gull		Engine	Nil
2	Cessna 402	26.6.73	17.30	Feringe	0	80	Take-off	Gull		Engine	Nil
3	Piper PA34-200	3.7.73	10.00	-	1000	140	Cruise	Buzzard		Fuselage	Nil
4	Cessna 402	26.7.73	11.36	Visby	300	110	Climb	Swallow		Wing	Nil
5	Piper PA23	2.10.73	14.40	Kalmar	0	80	Landing	Gull		Engine	Small Dent in nacelle
6	Piper PA31	25.10.73	19.30	Ludvika	300	130	Climb	-		Wing	Fracture in Wing Tip

STRIKES IN THE UK TO AIRCRAFT OF 5700 kg (12,500 lb) AND UNDER

	AIRCRAFT	DATE	TIME	LOCATION	ALTITUDE	IAS	PHASE	BIRD	NUMBER	PART STRUCK	DAMAGE
1	Piper Cherokee	5.1.73	14.45	White Waltham	60	70	Take-off	Pigeon	Single	Starboard wing	
2	Cessna 150	12.1.73	09.40	Denham	5	45	Take-off	Pigeon	Flock	Propeller	
3	Beagle Pup	21.1.73	17.07	Norwich	20	65	Landing	-	Flock	-	
4	Cessna 172	17.2.73	14.48	Swansea	3	80	Landing	Gull	Flock	Wing	
5	Piper Twin Commanche	18.2.73	16.19	Hurn	0	50	Landing	Pigeon	Flock	Wing	
6	Piper Aztec	21.2.73	16.30	Norwich	50	95	Take-off	Gull	Single	Wing	
7	Piper Twin Commanche	5.3.73	13.16	Carlisle	50	90	Take-off	Gull	Flock	Nose wheel door, damaged	
8	Piper Cherokee	19.3.73	09.20	Portsmouth	10	60	Landing	Gull	Flock	Fuselage	
9	Cherokee 140	26.3.73	14.03	Ronaldsway	300	85	Take-off	Gull	Single	Nose section	
10	Cessna 310	3.5.73	09.20	Perth	400	90	Take-off	Black-headed Gull	Flock	Propeller	Nil
11	Piper PA28	7.5.73	11.10	Hamble	0	55	Take-off	Gull	Flock	Wing	Nil
12	BO 209 Monsun	10.5.73	18.30	Glasgow	50	75	-	Gull	Flock	Undercarriage, fairing slightly bent and cracked	
13	Victa Airtourer	28.5.73	14.58	Glamorgan	-	75	Landing	Plover	Single	Wing, leading edge damaged	
14	Piper PA39	20.6.73	17.00	Oxford	250	60	Take-off	-	Single	Stbd Propeller, Stbd Cowling	Nil
15	Victa Airtourer	16.7.73	18.55	Glamorgan	-	80	Landing	Black-headed Gull	Single	Nose	Nil
16	BN2A Islander	20.7.73	14.45	Kirkwall	50	60	Landing	Gull	Single	Wing	Nil
17	Piper PA28	23.7.73	13.10	Lee-on-Solent	0	60	Landing	Gull	Single	Wing	Nil
18	Auster 21N Alpha	27.7.73	09.00	Ipswich	50	105	Climb	Gull	Flock	-	Nil
19	Piper Aztec	11.3.73	17.27	Belfast	-	-	Landing	Plover	Single	Fuselage	Nil

112

	AIRCRAFT	DATE	TIME	LOCATION	ALTITUDE	IAS	PHASE	BIRD	NUMBER	PART STRUCK	DAMAGE
20	Glos Airtourer	11.8.73	15.53	Glamorgan	0	75	Landing	Gull	Single	Propeller	Nil
21	Piper PA28	13.8.73	15.45	Glamorgan	80	75	Take-off	Pigeon	Single	Wing	Nil
22	Cessna 172	20.8.73	17.53	Jersey	10	60	Take-off	Gull	Single	Wing	Slight dent
23	Piper PA28	22.8.73	15.03	Glamorgan	0	100	Landing	-	Single	Wing	Nil
24	Piper PA28	30.8.73	14.20	-	800	120	Climb	Skylark	Single	Air intake	Nil
25	Thorpe T18	9.9.73	15.57	Glasgow	> 500	100	Landing	-	-	-	Nil
26	HS Dove	19.9.73	09.06	Ronaldsway	5	78	Landing	-	Single	Nose section	Nil
27	Piper PA30	22.9.73	09.13	Ronaldsway	0	60	Take-off	Black-backed Gull	Single	Wing, large dent on leading edge	
28	Cessna 172	24.9.73	12.17	Ronaldsway	0	75	Take-off	Sparrow	Single	Wing	Nil
29	Piper PA23	28.9.73	15.53	Blackpool	0	90	Landing	Gull	Flock	Wing, tip leading edge dented	
30	Piper Cherokee	9.10.73	16.53	Glasgow	300	70	Approach	Lapwing	Single	Wing	Nil
31	Piper Cherokee	18.10.73	09.30	Hamble	200	70	Approach	Gull	Single	Wing	Nil
32	Beagle Pup	29.10.73	12.19	Lydd	0	70	Landing	Gull	Flock	Propeller	Nil
33	HS Heron	6.11.73	15.33	Filton	0	80	Landing	Lapwing	Single	Aileron	Nil
34	Cessna 180	-	15.15	Denham	750	75	Approach	-	Single	Port wing	Nil
35	BN2 Islander	-	10.02	Glasgow	-	-	Landing	Gull	Single	Wing	Nil
36	Cessna 421	-	-	Glamorgan	0	-	Take-off	-	-	Propeller	Nil

REPORTABLE ACCIDENTS CAUSED BY BIRD STRIKE/INGESTION WORLD WIDE 1973

(Mainly Extracted from World Airline Accident Summary)

26. 2.73	Gates Lear 24	N454N	Machinery Buyers Corp	Atlanta Georgia	Executive	7	Crew:	2	0	0	Destroyed
							Pass:	5	0	0	
							Others:	0	1	0	

A Gates Learjet Model 24, N454RN operated by the Machinery Buyers Corp. crashed at 1012 eastern standard time on February 26, 1973, following the take-off from the DeKalb-Peachtree Airport, Atlanta, Georgia. The two crew members and five passengers were fatally injured, and one person on the ground sustained serious burns. The aircraft was destroyed by impact and ground fire. An apartment building was damaged, three parked vehicles were destroyed and another vehicle damaged by impact and fire.

The airplane departed from Runway 20L on an Instrument Flight Rules flight plan to Miami, Florida. Ground witnesses observed smoke trailing from the airplane as it crossed the field boundary. The DeKald-Peachtree Tower controller advised the crew of N454RN that the airplane's left engine appeared to be emitting smoke, whereupon the crew of N454RN responded that they had 'hit some birds'. The tower controller inquired whether N454RN was returning to land, and N454RN responded 'Don't believe we're gonna make it'.

The airplane initially collided with the roof of a three-storey apartment building approximately 2 miles south-southwest of the airport. The airplane came to rest in a ravine adjacent to a highway, 165 feet southwest of the damaged apartment building.

About 30 minutes after the crash the remains of 15 cowbirds were found within 150 feet of the Runway 2R (the departure end of Runway 20L) threshold. A municipal dump is located adjacent to the airport just east of Runway 2R/20L. During the investigation, large flocks of birds were observed on the airport and birds numbering in the thousands were seen swarming over the dump area.

The National Transportation Safety Board determines that the probable cause of this accident was the loss of engine thrust during take-off due to ingestion of birds by the engines, resulting in loss of control of the airplane. The Federal Aviation Administration and the Airport Authority were aware of the bird hazard at the airport; however, contrary to previous commitments, the airport management did not take positive action to remove the bird hazard from the airport environment. (NTSB–AAR–73–12)

Note: The left engine showed 14 separate strikes, and the right showed at least 5 strikes; the engine intake diameter is approximately 16 in, and area 182 sq in. The weight of a cowbird (Molothrus ater) is approximately 45 gm, compared with a starling (Sternus vulgaris) which is 85 gm.

30. 4.73	Boeing 747	VH-EBB	Qantas	Sydney Airport	Scheduled Passenger	366	Crew:	0	0	?	?
							Pass:	0	0	?	

Just after take-off the aircraft flew through a flock of sea gulls causing power loss on one engine and external damage to another. A third engine is reported to have failed completely. After dumping fuel a safe emergency landing was made back at Sydney.

12.12.73	Falcon 20	LN-FOE	Fred Olsens	Norwich Airport	Executive	9	Crew:	0	0	3	Substantial/ Destroyed
							Pass:	0	0	6	

The aircraft was taking-off at 15.37 hours (dusk) from Norwich airport and on becoming airborne, just over half-way along the 1840m long runway the crew saw a flock of birds ahead flying just above the ground. The pilot slightly increased the aircraft's climb attitude and the flock passed underneath. A few ///

seconds later a second flock was seen at a higher level directly in the aircraft's flight path. The pilot lowered the nose and the flock passed overhead. On re-establishing the climb a third flock was seen directly ahead, extending from ground level to well above the aircraft with no possibility of avoiding it. Almost immediately the crew heard the sound of multiple bird strikes on the aircraft. On both engines the RPM ran down very fast and EPR and TGT instrument readings also dropped. A bang was heard from the engines, followed by the sound of engines running down in a rough and abnormal manner. By this time the aircraft was at a height of 300 ft, still with the gear down. The speed had been 150 kts prior to impact. The pilot saw a field ahead and slightly to the left which he considered suitable for a forced landing, the pilot made a left turn and lined up the aircraft for an approach to the selected field avoiding trees at the approach end in spite of poor visibility and approaching darkness. A positive touch-down was made, the stall warning having sounded just before the aircraft hit the ground. All three landing gear legs were torn off and the aircraft came to rest after sliding for 135 metres on the fuselage belly. All occupants were evacuated through the main cabin door. There was no fuel leakage.

A total of approximately 35 dead Herring Gulls (Larus argentatus) and Black-Headed Gulls (Larus ridibundus) were found towards the end of the runway. The largest complete bird weighed 450 gm (1 lb). There was evidence of two firm and one glancing strikes on the airframe and each engine showed evidence of having ingested at least one bird. The left engine had suffered a hard strike on the fan, which is situated to the rear of the engine, eleven complete fan blades were broken off and eight others were partially broken off and bent. Some of the broken fan blades penetrated the shroud casing and other parts were driven forward and ingested into the core engine causing compressor damage sufficient to make it stall and thus cause the whole engine to run down. In the right core engine a group of three first stage rotor blades and ten second stage blades had been "feathered" with further damage and bird remains through the compressor. There were also bird remains in the bleed air ducting. The damage would have led to repeated compressor stalls and/or surging with subsequent loss of power. It should be noted that when the engines were certificated in July 1964, small and medium bird ingestion requirements were not applicable. The two pilots and hostess suffered cuts, abrasions and bruising, generally to the forehead and face, all were discharged from hospital within six days. The pilots' seats were equipped with shoulder harnesses of the fixed (non-inertia reel) type, which made it almost impossible to operate certain of the aircraft's equipment. The pilots were therefore only using the lapstraps.

At the time of the accident the Air Traffic personnel in the Control Tower had made their usual practice of looking for bird flocks, none were observed on or in the vicinity of the airport. At the time visibility was affected by approaching darkness and by condensation and rain droplets on the windows (weather conditions were, surface wind 240/15 to 25 knots, cloud 2/8 at 1500 ft, 6/8 at 2,700 ft, visibility 7 kms, recent moderate rain, temperature +3°c). However, part of the runway is hidden by a slight dip in the ground, where a substantial number of dead birds were found. Although a flock of gulls may have settled on or near the runway, the bird action co-ordinator believed it far more probable that the birds were part of an incoming flock preparing to land on the runway. This theory was supported by the arrival of other large bird flocks arriving from the northwest subsequent to the accident.

It had been observed that the gulls had recognised loafing areas, on the apron and grass areas adjacent to the control tower and threshold of runway 04. As a bird control measure the grass on these areas was allowed to grow long. However, at the time of the accident, the sward was limp and laid flat which probably reduced its effectiveness. If birds were observed in a dangerous position a vehicle was driven along the runway in the area where birds were congregated. Although this had some success the bird action co-ordinator considered that it was largely ineffective and had advised the Airport Management that bird distress call equipment (SAPPHO) and/or shell-crackers were necessary. However, because of shortage of finance and manpower, this had not been done.

116

ANALYSIS OF MILITARY BIRDSTRIKE DATA - 1973

1. The analysis for 1973 proved to be rather difficult since data from contributing countries contained different information, and some used the old format, whilst others used the new revised format. Data was received from:

- Belgian Air Force
- French Air Force
- French Navy
- Denmark
- Netherlands
- Portugal
- Spain
- Sweden
- UK
- USAFE

Data was also received from the Canadian Armed Forces (Europe), but too late to be included in the tables. They suffered 23 strikes and their information is attached at the end of the tables as Annex A.

2. The problems associated with data analysis should disappear once the revised form is used exclusively ie for 1974. Unfortunately there are few if any conclusions that can be drawn from the 1973 data, but in general the patterns are similar to those for 1972. It is suggested that detailed analysis of this and future data should be discussed at the 1975 BSCE meeting in Stockholm.

3. The French Air Force included some interesting notes with their data, and these are attached as Annex 'B'.

Annex A Canadian Forces Europe Data
Annex B French Air Force Notes.

MOD (DFS(RAF))
London

10 March 1975

119

AD F 616 196

TABLE 1. AIRCRAFT TYPE

TYPE	AIRCRAFT	NO OF STRIKES	NUMBER OF MOVEMENTS	STRIKES/10000 MOVEMENTS
1. **JET**				
RAF	Buccaneer	71	22732	31.23
	Canberra	26	47870	5.43
	Dominie	2	14962	1.33
	Gnat	18	58344	3.08
	Harrier	41	70106	5.84
	Hunter	36	95444	3.77
	HS125	2	8050	2.48
	Jet Provost	51	349018	1.46
	Lightning	21	88408	2.37
	Nimrod	27	20664	13.06
	Phantom	66	51757	12.75
	Victor	9	15130	5.94
	Vulcan	19	28338	6.70
	VC10	11	17282	6.36
	Types with Nil Strikes	-	6836	-
RDAF	F-35	5	15258	3. 3
	F-100	13	13564	10. 0
	F-104	11	18000	6. 1
	Hunter	9	8054	11. 2
	T-33	9	11930	7. 5
	Types with Nil Strikes	-		-
RSAF	A 32 SAAB 32	55	44800	12. 3
	T 32 SAAB 32	2	5800	3. 4
	S 32 SAAB 32	12	9600	14. 4
	T 35 SAAB 35	64	135500	4. 7
	S 35 SAAB 35	18	16100	11. 2
	AJ 37 SAAB 37	6	8900	6. 7
	SK 60 SAAB 105	22	39700	5. 5
	Types with Nil Strikes	-		-
SAF	Mirage	6	3103	19. 3
	Northrop F-5	1	2041	4. 9
	Saeta H A 200 E	1	1015	9. 8
	T-33	1	676	14. 7
	Types with Nil Strikes	-		-
PAF	T-37, T-33, F-86, Fiat G-91, B-707	None	23336	-
	Types with Nil Strikes	-		-
TOTAL	For RAF, RDAF, RSAF, SAF AND PAF only	638	1252318	5.09

116

TYPE	AIRCRAFT	NO OF STRIKES	NUMBER OF MOVEMENTS	STRIKES/10000 MOVEMENTS
2. JET				
USAFE	F-4	16		
	RF4	12		
	F-111	18		
	C-9	1		
	T-39	5		
	Types with NIL strikes C-135	-		-
F Navy	ETENDARD IV	8		
	F8E	2		
	Types with NIL strikes	-		-
RNLAF	NF-5	26	not available	
	F-104G	61		
	Types with NIL strikes	-		-
FAF	COMBAT: Mirage (tous types) Mystere IV A F 100, SMB2 Vautour (1) Jaguar.			2.93
	ECOLE ET LIAISON: CM 170 Fouga, T33			0.82
	TRANSPORT ET LIAISON: C 135 F Mystere XX (2)			2.88 4.22
	Types with NIL strikes	-		-
BAF	MIRAGE 5B	-	-	9.78
	F/TF 104G	-	-	9.37
	T33	-	-	3.57
	FALCON 20E	-	-	24.39
	FOUGA MAGISTER	-	-	1.55
	Types with NIL strikes	-	-	-
TOTAL	STRIKES - JET	787		

119

TYPE	AIRCRAFT	NO OF STRIKES	NUMBER OF MOVEMENTS	STRIKES/10000 MOVEMENTS
3. TURBOPROP				
RAF	Andover	13	33880	3.83
	Argosy	4	9097	4.39
	Belfast	7	10738	6.51
	Britannia	9	25898	3.47
	Hercules	34	86894	3.91
	Types with NIL strikes	-	684	-
USAFE	C-130	3		
	Types with NIL strikes	-		-
F Navy	BREGUET 1150 ATLANTIC	4		
	BREGUET 1050 ALIZE	1		
	NORD 262 FREGATE	3		
	Types with NIL strikes	-		-
FAF	C 160 TRANSALL			0.42
	N 262 Fregate			
	Types with NIL strikes	-		-
BAF	C130 H	-	-	1.86
	Types with NIL strikes	-	-	-
TOTAL	STRIKES - TURBOPROP	78		

180

4.

TYPE	AIRCRAFT	NO OF STRIKES	NUMBER OF MOVEMENTS	STRIKES/10000 MOVEMENTS
PISTON				
RAF	Basset	4	10662	3.75
	Chipmunk	2	261850	0.055
	Devon	5	15113	3.30
	Hastings	1	1958	5.10
	Shackleton	3	3918	7.65
	Varsity	17	89976	1.88
	Pembroke	1	10348	0.96
	Types with NIL strikes	-	26228	-
RDAF	C-54	3		
	C-47	0		
	Chipmunk	0		
	KZ-VII	0	3516	
	L-18C	0	1286	
	Types with NIL strikes	-		-
RSAF	SK 50 SAAB Safir 91	1	19100	0.5
	SK 61 Scottish Av Bulldog	-	20000	0
	Transport (mainly Piston)	1	8800	1.1
	Types with NIL strikes	-		-
SAF	DC-3	1	-	-
	Types with NIL strikes	-		-
PAF	Chipmunk, DO-27, T-6, C-45, C-47 NORD, DC-6	NONE	131502	-
	Types with NIL strikes	-		-
USAFE	T-29	8		
	C-97	2		
	Types with NIL strikes C131, C118, O2, C47	-		-
F Navy	PIPER PA31 NAVAJO	3		
	Types with NIL strikes	-		-

121

RNLAF	Beaver Types with NIL strikes Piper Super Cub	3 -	not	available -
FAF	N 2501 NORATLAS TRIPACER PA 22 JODEL D 140 Types with NIL strikes	 -		0.18 10.000 0.21 -
BAF	SF 260M Types with NIL strikes C119G-DC3-DC6- PEMBROKE	- -	- -	0.60 -
TOTAL	STRIKES - Piston	55		

TYPE	AIRCRAFT	NO OF STRIKES	NUMBER OF MOVEMENTS	STRIKES/10000 MOVEMENTS
5. **HELICOPTER**				
RAF	Puma (SA 330)	4	8071	4.95
	Sioux	1	3836	2.60
	Wessex	5	23823	2.09
	Whirlwind	1	23699	0.42
	Types with NIL strikes	-	540	-
RDAF	S-61	2	hours	per 10,000
	OH-6	0	2746	hours 7,3
	Alouette	0	2937	0
	Types with NIL strikes	-	2374	-
RSAF			hours	per 10,000 hours
		3	5002	5.4
	Types with NIL strikes	-		-
F Navy	ALOUETTE III	1		
	Types with NIL strikes	-		-
RNLAF	ALOUETTE III	4	not	available
	Types with NIL strikes	-		-
TOTAL	STRIKES - HELICOPTER	21		
TOTAL	STRIKES - ALL TYPES	941		

TABLE 2. AIRFIELD

Airfield RAF a	No of Strikes b	No of Movements c	Rate Per 10,000 Movts d
DOMESTIC			
Abingdon	2	25774	0.77
Aldergrove	2	79914	0.25
Barkston Heath	7	29718	2.35
Belfast Harbour	2	-	-
Benson	7	17163	4.08
Binbrook	2	12646	1.58
Brize Norton	9	33464	2.69
Cambridge	2	-	-
Chivenor	7	56649	1.23
Coltishall	4	20128	1.99
Coningsby	2	22444	0.89
Cottesmore	6	25412	2.36
Cranwell	2	72135	0.27
Fairford	4	8938	4.47
Finningley	2	30061	0.66
Kemble	2	23276	0.85
Kinloss	17	18567	9.15
Leeming	4	61538	0.65
Leuchars	9	24641	3.65
Lyneham	6	49323	1.21
Macrihanish	2	6515	3.07
Manby	2	63102	0.31
Marham	5	14040	3.56
Northolt	3	14691	2.04
Oakington	9	63875	1.40
Odiham	2	52724	0.37
Pershore	2	11080	1.80
St Mawgan	7	21160	3.30
Scampton	3	14032	2.13
Thorney Island	17	31348	5.42
Valley	6	92933	0.64
(MONA 1)			
Waddington	2	9083	2.20
Wittering	4	40359	0.99
Wyton	5	19728	2.53
Other airfields with single strikes	13		
FOREIGN			
Gutersloh	3	49349	0.76
Laarbruch	3	31781	0.94
Wildenrath	2	61167	0.32
Luqa	7	27640	2.53
Foreign airfields with single strikes	4		
EN ROUTE	188		
UNKNOWN	115		

a	b	c	d
RDAF			
DOMESTIC, strikes in own country			
Karup	2	27954	0.7
Aalborg	7	20124	3.5
Skrydstrup	13	20990	6.2
Vaerloese	1	21646	0.5
Tirstrup	0	Unknown	0
Vandel	0	8998	0
Aunoe	0	9453	0
Other Domestic Airfields with single strikes	-	-	-
FOREIGN		-	-
Italy	1	-	-
Other Foreign Airfields with single strikes		-	-
EN ROUTE	18	-	-
UNKNOWN	10	-	-
TOTAL	52		
RSAF			
DOMESTIC, strikes in own country			
F1	11	24800	4.4
3	2	13900	1.4
4	2	22900	0.9
5	7	42200	1.7
6	5	14400	3.5
7	9	20800	4.3
8	0	5900	0.0
10	5	21800	2.3
11	7	23700	3.0
12	8	16100	5.0
13	6	21800	2.8
15	3	16500	1.8
16/20	6	29900	2.0
17	8	15600	5.1
18	3	4700	6.4
21	3	18900	1.6
FOREIGN			
Other Foreign Airfields with single strikes -	-	-	-
ENROUTE			
UNKNOWN			
TOTAL	190	321000	5.9

125

a	b	c	d
SAF			
DOMESTIC AIRFIELDS			
Zaragoza	2		
Manises (Valencia)	5		
Moron (Sevilla)	1		
Sevilla	1		
Valladolid	1		
Other Domestic Airfields with single strikes			
FOREIGN			
Other Foreign Airfields with single strikes	-		
UNKNOWN			
EN ROUTE			
USAFE			
DOMESTIC AIRFIELDS N/A			
Other Domestic Airfields with single strikes			
FOREIGN			
Zaragoza AB, Spain	1		
Hahn AB, Germany	2		
Holbeach Range, UK	2		
Bardenas Range, Spain	2		
RAF Upper Heyford, UK	3		
Zweibrucken AB, Germany	5		
Ramstein AB, Germany	3		
RAF Alconbury, UK	1		
Incerlik CDI, Turkey	6		
Bitburg AB, Germany	1		
Chievres, Belgium	2		
Wiesbaden AB, Germany	4		
Lahr AB, Germany	3		
Other Foreign Airfields with single strikes	0		
UNKNOWN	4		
EN ROUTE	26		

F NAVY

a	b	c	d
DOMESTIC			
Landivisiau	5		
Lorient-Lawn Bishoue	2		
Niores Garons	2		
Lanveoc	2		
Beauvais	2		
Ajaccio	2		
Other Domestic Aerodromes with single strikes	1	-	-
FOREIGN			
Nil		-	-
Other Foreign Aerodromes with single strikes	-	-	-
EN ROUTE	6	-	-
UNKNOWN	0	-	-
RNLAF			
DOMESTIC AIRFIELDS			
Leeuwarden	19	24500	7.8
Twenthe	2	14000	1.4
Deelen	1	48145	0.2
Eindhoven	2	7700	2.4
Volkel	7	16600	4.2
Gilze-Rijen	6	13700	4.4
De Peel	1	3800	2.6
Other Domestic Airfields with single strikes			
FOREIGN			
Nil			
EN ROUTE	43		
UNKNOWN	13		

FAF

a	b	c	d
DOMESTIC, strikes in own country			
Bordeaux-Merignac			1.09
Clermont			0.34
Cognac			1.16
Colmar			0.42
Dijon			0.46
Istres			1.56
Luxeuil			0.74
Nancy-Ochey			0.91
Salon			0.27
Strasbourg			1.79
Tours			0.35
Villacoublay			1.38
Other Domestic Airfields with single strikes	8	-	-
FOREIGN		-	-
Other Foreign Airfields with single strikes		-	-
EN ROUTE	72	-	-
UNKNOWN	1	-	-
TOTAL	119		
BAF			
DOMESTIC, strikes in own country			
Kleine Brogel	-	-	7.22
St Truiden	-	-	2.35
Florennes	-	-	2.69
Beauvechain	-	-	1.96
Liege/Bierset	-	-	0.63
Goetsenhoven	-	-	0.60
Melsbroek	-	-	0
Koksijde	-	-	
Other Domestic Airfields with single strikes		-	-
FOREIGN		-	-
Bitburg (Germany)	1	-	-
Piacenza (Italy)	1	-	-
Bruggen (Germany)	1	-	-
Northolt (England)	1	-	-
Solenzara (France)	1	-	-
Other Foreign Airfields with single strikes	-	-	-
EN ROUTE	34	-	-
UNKNOWN	3	-	-
TOTAL	-	-	5.90

TABLE 2 A. SUMMARY OF LOCATION

DOMESTIC	390
FOREIGN	60
EN ROUTE	492
UNKNOWN	155
TOTAL	1097

139

TABLE 3. BIRD SPECIES

COMMON NAME	LATIN NAME	APPROX WT GR	CAT	NO OF STRIKES	% BASED ON 431
Iceland Gull	Larus Glauucoides	1500	B	1	
Greater Black Backed Gull	Larus Marinus	1600	B	3	
Lesser Black Backed Gull	Larus Fuscus	800	B	1	
Herring Gull	Larus Argentatus	1000	B	22	
Common/Black Headed Gull	L Canus/Ridibundus	250/400	B	115	33.0
TOTAL GULLS				142	33.0
Oystercatcher	Haemotopus Ostralegus	500	B		1.1
Lapwing	Vanellus Vanellus	200	B	52	12.0
Pigeon	Columba Palumbus	600	B	51	11.8
Vulture	Gyps Fulvus	5400	D	1	0.2
Starling	Sturnus Vulgaris	100	A	22	5.1
Golden Plover	Pluvalis Apricaria	200	B	5	1.1
Skylark	Alauda Arvensis	40	A	10	2.3
Finches			A	34	0.9
Corvids	Corvidae Spp	4-500	B	20	4.6
Sparrow Hawk	Accipter Nisus	100	A	2	0.4
Curlew	Numenius Spp	700	B	5	1.1
Pheasant	Phasianus Colchicus	1134	B	2	0.4
Woodcock	Scolopax Rusticola	300	B	1	0.2
Mallard	Anas Platyrhynchos	900	B	2	0.4
Eider Duck	Somateria Mallissima	1100	B	1	0.2
Shellduck	Tadorna Tadorna	1600	B	1	0.2
Turdidae	Spp Turdidae	70/115	A/B	11	2.5
Swift/Swallow/Martin	Hirundinidae	80/40	A	29	6.7
Tern	Sterna Hirundo	100	A	3	0.7
Blue Tit etc	Parus Spp	14	A	4	0.9
Great Skua	Catharacta Skua	1600	B	1	0.2
Pipit	Anthus Spp	23	A	2	0.4
Wader	Charadriforme	-	-	2	0.4
Bat	-	-	-	1	0.2
Buzzard	Buteo Buteo	1000	B	6	1.4
Partridge	Perdix Perdix	300	B	7	1.6
Owl	Strigiforme	-	-	2	0.4
Kestrel	Falco Tinnunculus	210	B	6	1.4
Passeriforme	-	-	A	21	4.8
Red Breasted Mergauzer	Mergus Serrator	1000	B	1	0.2
Little Bustard	Otis Tetrax	900	B	4	0.9
Bean Goose	Anser Fabalis	2500	C	1	0.2
Quail	Coturnix	220	B	1	0.2
Hawk	Spp Accipiter	910	B	1	0.2
Grey Heron	Ardea Cinerea	1800	B	1	0.2
Anseriforme	-		B	1	0.2
Unknown				685	
TOTAL	-	-	-	1116	

131

TABLE 4 MONTH OF YEAR - STRIKES IN OWN COUNTRY ONLY

1. RAF

MONTH a	WEIGHT UNKNOWN b	CAT A & CAT B c	CAT C d	CAT D e	TOTAL f	NUMBER OF MOVEMENTS g	STRIKES PER 10,000 MOVEMENTS h
January	2	15			17	116665	1.45
February	5	11			16	128681	1.24
March	16	15			31	159410	1.94
April	8	11			19	119878	1.58
May	8	9			17	131102	1.29
June	7	15			22	144997	1.51
July	13	36			49	153378	3.19
August	7	23			30	131773	2.27
September	12	16			28	116502	2.40
October	16	33			49	129418	3.78
November	10	19			29	107273	2.70
December	4	10			14	66892	2.09
Month Unknown	-	-			-	-	-
TOTAL	108	213			321	1505969	2.13

2. RDAF

MONTH	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	NUMBER OF MOVEMENTS	STRIKES PER 10,000 MOVEMENTS
January			1		1	5922	1.7
February			1		1	8760	1.1
March	4	1	1		6	10230	5.9
April	3	1			4	8175	4.9
May	2				2	12368	1.6
June	1		1		2	10355	1.9
July			3		3	11100	2.7
August	2	2	5		9	12550	7.2
September	5	2	1		8	9700	8.2
October	7		5		12	12371	9.7
November		1	2		3	8234	3.6
December					0	4324	0
Month Unknown						-	-
TOTAL	24	7	20		51	114089	4.5

3. RSAF

a	b	c	d	e	f	g	h
January					1	19600	0.5
February					2	29000	0.7
March					14	33900	4.1
April					25	24300	10.3
May					20	35800	5.6
June					20	27900	7.2
July					15	12200	12.3
August					29	33200	8.7
September					24	30800	7.8
October					29	34900	8.3
November					9	27000	3.3
December					2	12500	1.6
Month Unknown					-	-	-
TOTAL					190	321000	5.9

4 SAF

MONTH a	WEIGHT UNKNOWN b	CAT A & CAT B c	CAT C d	CAT D e	TOTAL f	NUMBER OF MOVEMENTS g	STRIKES PER 10,000 MOVEMENTS h
January		1			1		
February							
March		1			1		
April							
May		1			1		
June		1			1		
July		2			2		
August							
September		1			1		
October							
November		1			1		
December		2			2		
Month Unknown						-	-
TOTAL		10			10		

5. USAFE

a	b	c	d	e	f	g	h
January	3				3		
February	1				1		
March	5				5		
April	2				2		
May	4	2			6		
June	5	1			6		
July	14				14		
August	5	1			6		
September	2	2			4		
October	5	3			8		
November	3	2			5		
December	3	2			5		
Month Unknown	0				0		
TOTAL	52	13			65		

6 FR NAVY

a	b	c	d	e	f	g	h
January	1	1			2		
February	1	1			2		
March							
April	1				1		
May	1	1			2		
June	-	2			2		
July	2				2		
August	-	-			-		
September	2	4			6		
October	3	-			3		
November	-	1			1		
December	-	1			1		
Month Unknown	-				-		
TOTAL	11	11	-		22		

7 RNLAF

a	b	c	d	e	f	g	h
January	-	1			1	not available	
February	-	1			1		
March	8	6			14		
April	3	2			5		
May	3	3			6		
June	8	1			9		
July	8	5			13		
August	5	8			13		
September	8	3			11		
October	13	4			17		
November	-	-			-		
December	2	-			2		
Month Unknown	2	-			2	-	-
TOTAL	60	34			94	146700	6.4

8 FAF

MONTH a	WEIGHT UNKNOWN b	CAT A c	CAT B d	CAT C & D e	TOTAL f	NUMBER OF MOVEMENTS g	STRIKES PER 10,000 MOVEMENTS h
January	1		6	-	7		1.09
February	2		1	-	3		0.51
March	16		9	1	26		2.83
April	2		3	-	5		0.77
May	6		2	1	9		0.99
June	-		9	-	9		1.17
July	6		3	-	9		1.05
August	2		5	-	7		1.19
September	4		1	1	6		0.72
October	18		11	1	30		3.16
November	1		4	-	5		0.62
December	2		1	-	3		0.18
Month Unknown						-	-
TOTAL	60		55	4	119		

9. BAF

a	b	c	d	e	f	g	h
January	-	-	-	-	-	-	-
February	-	-	-	-	-	-	1.32
March	-	-	-	-	-	-	6.11
April	-	-	-	-	-	-	3.19
May	-	-	-	-	-	-	3.65
June	-	-	-	-	-	-	4.05
July	-	-	-	-	-	-	4.39
August	-	-	-	-	-	-	3.25
September	-	-	-	-	-	-	2.24
October	-	-	-	-	-	-	8.78
November	-	-	-	-	-	-	2.01
December	-	-	-	-	-	-	-
Month Unknown	-	-	-	-	-	-	-
TOTAL	-	-	-	-	-	-	3.63

TABLE 4A - MONTH OF YEAR - STRIKES IN OWN COUNTRY (RAF, RDAF, RSAF, FAF)

Month	Weight Unknown	Cat A & B	Cat C & D	Total	Number of Movements	Strikes Per 10,000 Movements
January	4	22		26	206407	1.25
February	9	13		22	225261	0.97
March	50	26	1	77	295412	2.60
April	38	15		53	217288	2.44
May	36	11	1	48	270179	1.77
June	28	25		53	260175	2.03
July	34	42		76	262392	2.89
August	40	35		75	236346	3.17
September	45	20	1	66	240335	2.74
October	70	49	1	120	271625	4.41
November	20	26		46	223152	2.06
December	8	11		19	250376	0.75
TOTAL	382	295	4	681	2958948	2.30

TABLE 5 - AIRSPEED

AIRSPEED (kts IAS)	WEIGHT UNKNOWN	CAT A & B	CAT C & D	TOTAL	% BASED ON 732
0 - 80	1	7		8	1.1
81 - 100	11	71	1	83	11.3
101 - 150	34	100	2	136	18.6
151 - 200	29	64	1	94	12.8
201 - 250	35	33		68	9.3
Over 250	249	89	1	339	46.3
Airspeed Unknown	149	61		210	-
TOTAL	508	429	5	942	-

TABLE 5A - ALTITUDE (RDAF, RSAF, FAF, BAF)

ALTITUDE (ft)	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON 392
0 - 499	143	5	49	2	199	50.8
500 - 999	58	6	20	1	85	21.7
1000 - 2500	77	1	15	1	94	24.0
Over 2500	9	1	4		14	3.6
Altitude Unknown	32	1	1		34	-
TOTAL	319	14	89	4	426	-

Notes:-

5.1 When the Altitude is not specifically stated, but the Flight Stage is quoted as take-off or landing the 0 to 499 ft division can be assumed.

5.2 Birds struck on the runway should be included in the 0 to 499 ft division.

5.3 The percentages should be based on the known totals.

38

TABLE 5A - ALTITUDE (RAF, RNLAF, F NAVY, USAFE, SAF)

ALTITUDE (ft)	WEIGHT UNKNOWN	CAT A & B	CAT C & D	TOTAL	% BASED ON 526
0 - 200	41	170		211	40.1
201 - 800	132	73	1	206	39.1
801 - 2500	68	25		93	17.7
Over 2500	10	6		16	3.0
Altitude Unknown	138	37		175	-
TOTAL	389	311	1	701	-

TABLE 6 - FLIGHT STAGE

STAGE	WEIGHT UNKNOWN	CAT A & B	CAT C & D	TOTAL	% BASED ON 942
Taxying	1	1		2	0.2
Take-off	85	101	2	188	19.9
Low Level En-Route and Attack	337	109	1	447	47.4
Climb	8	5		13	1.4
Cruise	29	6	1	36	3.8
Recovery	5	5	1	11	1.1
Descent	5	4		9	0.9
Final Approach	19	21		40	4.2
Landing	57	113	1	171	18.1
Touch & Go/Overshoot	9	16		25	2.6
Unknown	152	28		180	-
TOTAL	707	409	6	1122	-

Notes:

6.1 It is not possible to provide a precise definition of these stages as the altitudes vary with aircraft type, and particular operation.

6.2 Birds struck on the runway should be divided equally between take-off and landing.

6.3 The percentage should be based on the total where the stage is known.

6.4 Low Level, En-Route and attack, is taken as being below 2500 feet AGL.

6.5 Cruise is taken as being above 2500 feet AGL.

6.6 Take-off, landing, and touch and go/overshoot, are defined as being when the aircraft is within the airfield boundary, and below 500 feet (152 metres) AGL.

TABLE 7 PART OF AIRCRAFT STRUCK (RAF, RNALF, F NAVY, SAF, USAFE)

PART	WEIGHT UNKNOWN	CAT A & B	CAT C	CAT D	TOTAL	% BASED ON 753
Radome	21	16			37	4.9
Nose Section	45	44			89	11.8
Wing	66	71			137	18.2
Rotors	2	5			7	0.9
Powerplant	108	87		1	196	26.0
Canopy/ Windscreen	83	49			132	17.5
Fuselage	44	31		1	76	10.1
Landing Gear	15	25			40	5.3
Empennage	6	4			10	1.3
Underwing Stores & Tanks	14	15			29	3.8
Part Unknown	26	16			42	-
TOTAL	430	363		2	795	-

TABLE 7A SIGNIFICANT STRIKES

						%
Significant					115	16.8
Not Significant					570	83.2
TOTAL					685	-

Notes:

7.1 The Total in table 7 may be higher than the others, as one bird can hit several parts.

7.2 The percentage should be based on incidents where the part struck is known.

7.3 The definition of Significant is based on ICAO Working Paper No 294 as follows:

(a) Catastrophic - loss of life or destruction of aircraft

(b) (i) Cracked or shattered windscreen

(ii) Torn metal skinning on any part of aircraft

(iii) Deformed secondary (or primary) structure

(iv) Damage to engines sufficient to cause shut-down, or unrecoverable loss of power.

7.4 Multiple strikes should only be counted as one strike, unless for example two engines or both wings are struck in which case two strikes should be recorded.

TABLE 7 PART OF AIRCRAFT STRUCK (RDAF, FAF, RSAF, BAF)

PART	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% Based on 413
Nose (excluding radome and windscreen)	22	1	5		28	6.7
Radome	10	1	4		15	3.6
Windscreen	56	3	8	1	68	16.5
Fuselage (excluding the above)	79	3	22		104	25.2
Engine:-						
1 engine struck 2 out of 3 struck 2 out of 4 struck 3 out of 4 struck all struck (on multi-engined aircraft)	46	3	29	1	79	19.1
Wing	42	2	24	1	69	16.7
Rotor/Propeller	-	-	-	-	-	
Landing Gear	9	4	19	1	33	8.0
Empennage	2	-	-		2	0.4
Underwing Stores/Tanks	12	-	3		15	3.6
Part Unknown	69	-	2		71	-
TOTAL	347	17	116	4	484	-

Notes:

7.1 The Total in Tables 7 and 7A/B may be higher than other tables, as one bird can strike several parts.

7.2 The percentage should be based on incidents where the part struck is known.

7.3 Multiple strikes should be counted as one strike, unless for example both wings or both landing gear are struck, when two incidents should be recorded.

TABLE 7A - EFFECT OF STRIKE (RDAF, RSAF, BAF)

EFFECT	WEIGHT UNKNOWN	CAT A	CAT B	CAT C	CAT D	TOTAL	% BASED ON 316
Loss of Life/Aircraft	3					3	0.9
Flight Crew Injury							
Major							
Minor							
Slight	2					2	0.6
Premature Engine Change:-							
on single engined aircraft	9		5			14	4.4
1 on a 2 engined "							
1 " 3 " "							
1 " 4 " "							
2 " 3 " "							
2 " 4 " "							
3 " 4 " "							
all engines on a multi							
Windscreen Cracked/Broken	6					6	1.9
Radome Changed	1					1	0.3
Deformed Structure	11		3			14	4.4
Skin Torn	10		2			12	3.8
Skin Dented	15		4			19	6.0
Propeller/Rotor Damaged							
Aircraft System Lost	1		1			2	0.6
Underwing Stores/Tanks damaged	3		2			5	1.6
Miscellaneous	11		2			13	4.1
Nil Damage	194	8	23			225	71.2
Unknown							
TOTAL	266	8	42			316	-

Notes:

7A.1 Multiple strikes should be counted as one strike, unless for example both wings are damaged, or both windscreens are broken, in which case two incidents should be recorded.

7A.2 Definition of Injury requiring medical treatment:
- Major - causing absence of 21 days or over
- Minor - " " " 7 to 21 days
- Slight - Injury not in above 2 categories.

7A.3 Injuries as a consequence of a strike, eg, ejection injuries should be included.

7A.4 Aircraft system lost includes for example electrical, hydraulic, brake, etc.

TABLE 7B - EFFECT - AIRSPEED - WEIGHT OF BIRD (RDAF, RSAF, RAF)

EFFECT	AIRSPEED	0-80		81-100		101-150		151-200		201-250		over 250	
	WEIGHT	A&B	C&D	A&B	C&D	A&B	C&D	A&B	C&D	A&B	C&D	A&B	C&D
Loss of Life/Aircraft													
Flight Crew Injured												1	
Engine Prematurely Changed		1								2		2	
Windscreen Cracked/ Broken												1	
Radome Changed													
Deformed Structure												2	
Skin Torn								1		1		3	
Skin Dented						1		2				2	
Propeller/Rotor Damaged													
Aircraft System Lost										1			
Underwing Stores/Tanks Damaged						2		1					
TOTAL		1				3		4		4		11	

Notes:

7B.1 The TOTAL in Table 7B will be very small, as those incidents where the airspeed or the bird weight are unknown, together with the non damaging strikes, have been omitted.

APPENDIX 'A'
BSCE/A/2

BIRD STRIKE COMMITTEE EUROPE

MILITARY AIRCRAFT

BIRD STRIKE ANALYSIS

CANADIAN FORCES EUROPE (GERMANY)

19[illegible]

NOTES:-

0.1 The following should NOT be included in this Analysis
(a) all civil operated aircraft
(b) all Foreign aircraft.

0.2 Strikes to aircraft in (b) should be notified to their country of origin on an annual basis.

0.3 Any explanatory notes should be included as Appendix A to this Analysis

0.4 Tables 1, 2, 3, 5, 6 and 7 should include strikes reported World-Wide, Table 4 should be for their own country only. Table 3 could also be informative if restricted to own country.

0.5 The Total column of Tables 1A, 2A, 5, 5A and 6 should be identical.

0.6 Birds found dead on the airfield should only be included if there is clear evidence that the bird was killed by impact.

TABLE 1 AIRCRAFT TYPE

TYPE	AIRCRAFT	NUMBER OF STRIKES	NUMBER OF MOVEMENTS	STRIKES PER 10,000 MOVEMENTS
JET	CF 104	17		
	Types with NIL strikes T33, 101	-		-
TURBOPROP	Hercules C130	2		
	Types with NIL strikes	-		-
PISTON				
	Types with NIL strikes	-		-
HELICOPTER (See Note 1.3)	Kiowa CH 136	4	hours	per 10,000 hours
	Types with NIL strikes	-		-
UNKNOWN			-	-

TABLE 1A SUMMARY OF AIRCRAFT TYPES

Piston Turboprop Jet Unknown		-	-
TOTAL - Including those with NIL strikes	23	20,138.5	11.42
Helicopters (hours)			

Notes:-

1.1 There is a minimum of 2 movements per flight.

1.2 Movements for each aircraft type with nil strikes must be included.

1.3 If for reasons of National Security all of the Table cannot be completed, at least the Strike Rates should be given.

1.4 Helicopter strikes should be quoted against flying hours, rate is strikes/10,000 hours.

146

- TABLE 2 AIRFIELD

AIRFIELD	NUMBER OF INCIDENTS	NUMBER OF INCIDENTS	STRIKES PER 10,000 MOVEMENTS
DOMESTIC, strikes in own country (Germany)			
Baden - Soellingen	5		
Lahr	1		
Other Domestic Airfields with Single Strikes		-	-
FOREIGN		-	-
NIL		-	-
Other Foreign Airfields with Single Strikes		-	-
EN ROUTE	17	-	-
UNKNOWN		-	-
TOTAL	23		11.42

Notes:-

2.1 Strikes encountered away from airfields should be tabled as En-Route, i.e. outside the airfield boundary and/or higher than 152 metres (500 feet) a.g.l.

2.2 By reason of geographic location certain islands may have to be regarded as "Foreign".

2.3 The movement date should include positioning, test and training movements.

2.4 Airfields with less than 10,000 movements should be included in the table, but the rate will be subject to error.

TABLE 3 BIRD SPECIES

COMMON NAME	LATIN NAME	APPROX WEIGHT	CATEGORY	NUMBER OF STRIKES	% BASED ON ....
Pigeon			B	2	
Hawk			B	1	
Pheasant			B	1	
Crow			B	1	
Blackbird			A	1	
Unknown	-	-	-	17	-
TOTAL		-	-	23	-

Notes:-

3.1 Bird weights and Latin names can be obtained from Canadian Field Note. No. 51, by G. Kaiser, unless there is positive evidence to the contrary, the AVERAGE weight should be assumed.

3.2 The bird Categories based on current Civil Airworthiness requirements are:-
- CAT A below ·11 kg (¼ lb)
- CAT B ·11 kg to 1·81 kg (¼ to 4 lb)
- CAT C over 1·81 kg to 3·63 kg (4lb to 8lb)
- CAT D over 3·63 kg (8 lb)

3.3 Those birds not positively identified should be tabled as Unknown.

3.4 Large (CAT C or D) birds are often not positively identified, but the Category these are assumed to be in should be stated.

3.5 Percentages should be based on the total of identified birds.

3.6 Table 3 could be repeated restricted to own country only.

TABLE 4 MONTH OF YEAR - STRIKES IN OWN COUNTRY ONLY

MONTH	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	NUMBER OF MOVEMENTS	STRIKES PER 10,000 MOVEMENTS
January	-	-	-	-	-		
February	-	-	-	-	-		
March	1	1	2	-	4		
April	-	-	-	-	-		
May	2	1	-	-	3		
June	-	-	2	-	2		
July	1	-	1	-	2		
August	1	1	1	-	3		
September	1	1	-	-	2		
October	-	2	2	-	4		
November	1	-	-	-	1		
December	-	-	-	-	-		
Month Unknown	2	-	-	-	2	-	-
TOTAL	9	6	8	0	23	20.138.5	11.42

Notes:-
4.1 **Restricted to strikes in own** country only, in order to determine domestic problem.
4.2 **Approximate figures** may have to be used for monthly movements.

TABLE [illegible] AIRSPEED

AIRSPEED (kts IAS)	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON 19
0 - 80	-	2	3	-	5	27
81 - 100	-	1	-	-	1	5
101 - 150	-	1	1	-	2	11
151 - 200	1	-	-	-	1	5
201 - 250	-	-	1	-	1	5
Over 250	5	1	3	-	9	47
Airspeed Unknown	3	1	-	-	4	-
TOTAL	9	6	8	0	23	-

TABLE 5A ALTITUDE

ALTITUDE (ft)	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON 16
0 - 499	-	2	5	-	7	44
500 - 999	1	2	1	-	4	25
1000 - 2500	2	1	1	-	4	25
Over 2500	1	-	-	-	1	6
Altitude Unknown	5	1	1	-	7	-
TOTAL	9	6	8	0	23	-

Notes:-

1. When the altitude is not specifically stated, but the Flight Stage is quoted as take-off or landing the 0 to 499 ft division can be assumed.
2. Birds struck on the runway should be included in the 0 to 499 ft division.
3. The percentages should be based on the known totals.

150

TABLE 6 FLIGHT STAGE

STAGE	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON ..20...
Taxying	-	-	1	-	1	5
Take-off	-	-	2	-	2	10
Low level En-Route and Attack	6	5	4	4	15	75
Climb	-	-	-	-	-	
Cruise	-	-	-	-	-	
Recovery	-	-	-	-	-	
Descent	-	-	-	-	-	
Final Approach	-	-	-	-	-	
Landing	1	-	1	-	2	10
Touch & Go/Overshoot	-	-	-	-	-	
Unknown	2	1	-	-	3	-
TOTAL	9	6	8	0	23	-

Notes:-

6.1 It is not possible to provide a precise definition of these stages as the altitudes vary with aircraft type, and particular operation.

6.2 Birds struck on the runway should be divided equally between take-off and landing.

6.3 The percentage should be based on the total where the stage is known.

6.4 **Low Level, En Route and attack, is taken as being below 2500 feet a g l.**

6.5 **Cruise is taken as being above 2500 feet a g l.**

6.6 **Take-off, landing, and touch and go/overshoot, are defined as being when the aircraft is within the airfield boundary, and below 500 feet (152 metres) a g l.**

TABLE 7 PART OF AIRCRAFT STRUCK

PART	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% Based on 16 ....
Nose (excluding radome and windscreen)	1	1	-	-	2	12.5
Radome	-	-	2	-	2	12.5
Windscreen	1	2	1	-	4	25.0
Fuselage (excluding the above)	1	-	1	-	2	12.5
Engine:-	-	-	-	-	-	-
1 engine struck						
2 out of 3 struck						
2 out of 4 struck						
3 out of 4 struck						
all struck (on multi-engined aircraft)						
Wing	1	-	-	-	1	6.25
Rotor / Propeller	-	1	2	-	3	18.75
Landing Gear	-	-	1	-	1	6.25
Empennage	-	-	-	-	-	-
Underwing Stores / Tanks	1	-	-	-	1	6.25
Part Unknown	4	2	1	-	7	-
TOTAL	9	6	8	-	23	160

Notes:

7.1 The Total in Table 7 and 7A may be higher than other tables, as one bird can strike several parts.

7.2 The percentages should be based on incidents where the part struck is known.

7.3 Multiple strikes should be counted as one strike, unless for example both wings or both landing gears are struck, when two incidents should be recorded.

TABLE 7A   EFFECT OF STRIKE

EFFECT	Weight Unknown	CAT A	CAT B	CAT C	CAT D	TOTAL	% Based on ...23...
Loss of Life/Aircraft	-	-	-	-	-	-	
Flight Crew Injury	-	-	-	-	-	-	
Major							
Minor							
Slight							
Premature Engine Change:-	-	-	-	-	-	-	
on single engined aircraft							
1 on a 2 engined "							
1 " 3 " "							
1 " 4 " "							
2 " 3 " "							
2 " 4 " "							
3 " 4 " "							
all engines on a multi							
Windscreen Cracked / Broken	-	-	-	-	-	-	
Radome Changed	-	-	-	-	-	-	
Deformed Structure	-	-	-	-	-	-	
Skin Torn	1	-	1	-	-	2	8%
Skin Dented	1	-	1	-	-	2	8%
Propeller/Rotor Damaged	-	-	-	-	-	-	
Aircraft System Lost	-	-	-	-	-	-	
Underwing Stores / Tanks damaged	1	-	-	-	-	1	4%
Miscellaneous	-	-	-	-	-	-	
Nil Damage	6	6	6	-	-	18	80%
Unknown							
TOTAL	9	6	8	0	0	23	100%

Notes:-

7A.1 Multiple strikes should be counted as one strike, unless for example both wings are damaged, or both windscreens are broken, in which case two incidents should be recorded.

7A.2 Definition of injury requiring medical treatment:

Major - causing absence of 21 days or over
Minor - " " of 7 to 21 days
Slight - injury not in above 2 categories.

7A.3 Injuries as a consequence of a strike, e.g. ejection injuries should be included

7A.4 Aircraft system lost includes for example electrical, hydraulic, brakes, air conditioning, de-icing.

TABLE 78 EFFECT - AIRSPEED - WEIGHT OF BIRD

EFFECT	AIRSPEED / WEIGHT	0-80 A&B	C&D	81-100 A&B	C&D	101-150 A&B	C&D	151-200 A&B	C&D	201-250 A&B	C&D	over 250 A&B	C&D
Loss of Life/Aircraft		-	-	-	-	-	-	-	-	-	-	-	-
Flight Crew Injured		-	-	-	-	-	-	-	-	-	-	-	-
Engine Prematurely Changed		-	-	-	-	-	-	-	-	-	-	-	-
Windscreen Cracked/Broken		-	-	-	-	-	-	-	-	-	-	-	-
Radome Changed		-	-	-	-	-	-	-	-	-	-	-	-
Deformed Structure		-	-	-	-	-	-	-	-	-	-	-	-
Skin Torn		-	-	-	-	-	-	-	-	-	-	1	-
Skin Dented		-	-	-	-	-	-	-	-	1	-	-	-
Propeller/Rotor Damaged		-	-	-	-	-	-	-	-	-	-	-	-
Aircraft System Lost		-	-	-	-	-	-	-	-	-	-	-	-
Underwing Stores/Tanks Damaged		-	-	-	-	-	-	-	-	-	-	-	-
TOTAL										1		1	

Notes:-

78.1 The TOTAL in Table 78 will be very small, as those incident where the airspeed or the bird weight are unknown, together with the non damaging strikes, have been omitted.

FRENCH AIR FORCE

EXPLANATORY NOTES

TABLE 1

- Pour une même activité aérienne et des profils de mission sensiblement identiques, les dommages subis par l'aviation d'école de transport et de liaison sont à peu près constants. L'augmentation du nombre d'impacts est à reporter sur les seuls avions de combat.

- Le taux élevé du Vautour II B (3,61 en 1972) se confirme en 1973 (4,96). Plus que la conception de l'appareil la zone de travail doit être mise en cause.

- Le taux du Mystère 20, (2,4 en 1972) augmente en 1973 (4,22). La plus grande vulnérabilité que l'on pourrait attribuer à l'emplacement des réacteurs même dans le cas d'un impact sur la cellule n'est pas prouvée.

Il n'y a pas eu de collisions avec les hélicoptères.

Comparaison entre 1972 et 1973 par type d'appareils (combat, école, liaison).

	1972	1973
Mirage III (tous types)	1,75	3,27
Mystère IV A	1,41	1,40
Vautour II B	3,61	4,96
F 100	2,16	2,94
SMB 2	0,96	1,35
JAGUAR	-	4
CM 170	0,35	0,46
T 33	0,46	0,97

... / ...

Table 2

Le liste des aérodromes est en augmentation de même que le pourcentage global des impacts à proximité des terrains : 30% en 1972, 40% en 1973.

SALON DE PROVENCE a eu des problèmes particuliers avec les mouettes dans le courant de l'été 1973.

Pour les aérodromes qui figurent sur les listes 72 et 73, les nombres d'impacts sont trop peu élevés pour tirer des conclusions sur les résultats des mesures prises, notamment à VILLACOUBLAY.

Table 3

Le classement des espèces en fonction du nombre d'impacts dans lesquelles elles sont impliquées reste inchangé : pigeons et mouettes sont toujours en tête.

Table 4

Les courbes qui figurent dans le bulletin de sécurité des vols * n° 117 page 11 montrent à quel point les migrations de printemps et surtout d'automne ont été néfastes. La différence du nombre total d'impacts de 72 à 73 peut leur être attribuée .

Tableau 7 A et 7 B

Les renseignements fournis par la fonction technique ne permettent pas de remplir ces deux tables. Le Bulletin de Sécurité des Vols donne cependant une idée de la répartition des dommages.

Les collisions d'oiseaux n'ont entraîné aucun accident aérien grave.

---

* Les statistiques qui figurent dans le bulletin sont faites à partir des fiches d'incidents et non des fiches de compte rendu de collision. La différence de 5 impacts correspond à des collisions qui n'ont entraîné aucun dommage à l'appareil et pour lesquels il n'y a pas eu établissement d'une fiche d'incident.

DISPERSAL OF GULLS FROM THE AIRPORT ENVIRONMENT

John F. Stout

Andrews University, Berrien Springs, Mich., U.S.A.

Introduction

According to U.S. Air Force records and information contained in the report of the Ninth Meeting of the BSCE, gulls are the most frequent species involved in air strikes with both civil and military aircraft. As significant proportions of these gull-aircraft collisions have occurred during landing and take-off, long term dispersal of gulls from the immediate airport environment is important.

Numerous dispersal procedures have been developed with varying degrees of effectiveness. Scaring procedures, including playback of distress calls and use of pyrotechnics, have generally not achieved long term dispersal of the gulls. These birds tend to return to the scaring site relatively quickly, and may habituate to the procedures used.

Over the past two years we have developed more effective dispersal procedures with the support of contracts from the U.S. Air Force, and the Smithsonian Institution.

Saul (1967) reported effective long term dispersal by using formalin preserved corpses of gulls. Based on these results and our previous work with sea gull models we have successfully developed artificial models of gulls and have structured a dispersal program involving the use of these models and distress call playbacks.

Methods

Experiments and observations on aggregations of the Glaucous-winged Gull (Larus glaucescens) were made on Shemya Island, Alaska between 5 August and 22 August 1973.

Studies were conducted on aggregations of Ring-billed Gulls (Larus delawarensis) at Ellington AFB, Texas and 1 January to 18 January 1974. The experiments made at Ellington AFB were based on the results of our work at Shemya AFB.

Experiments were conducted on Colville Island, Flower Island and the Whidbey Naval Air Station (WNAS) Sanitary Landfill. These

experiments were conducted between 0600 hrs and 1900 hrs from 15 June to 21 August 1974. Experiments in a colony involving the Distress call were conducted only at the end of the reproductive season so as to cause as little disturbance as possible.

Four types of models were constructed. The first consisted of a taxidermy mounted head and neck of a real gull mounted on a wooden body of approximately the normal body shape and size. Real wings were folded and attached to the wooden body. The second model type was similar to the one just described except the head, neck and wings were molded from fiberglass components, painted normal body colors of L. glaucescens, and attached to the wooden body. The third model type was a complete taxidermy mount of a dead gull. This was used in conjunction with the fourth model type which was a molded fiberglass whole mount of a dead gull.

Experiments Using Visual Stimuli

Two taxidermically mounted model gulls in choking postures were placed on the mudflat along the west side of the Upper Lake on Shemya Island where gulls frequently aggregated. The response to these models by the gulls was noted.

At Ellington AFB six gull models were constructed that consisted of a taxidermy-mounted head and neck of a real gull mounted on a wooden body of approximately the normal body size. The head was mounted for each experiment in the Aggressive Upright display posture (Tinbergen, 1959). Wings were folded and attached to the wooden body on five of the models. The sixth model had the wings out-stretched as before flight. These models were placed in areas where gulls were loafing or where they were frequently observed. Time was recorded from the placing of the models, to the return of the first bird. The behaviors of the reacting gulls were carefully noted.

The following experiments were conducted at the Pasadena Sanitary Landfill near Ellington A.F.B. to determine the effectiveness of the models in different positions.

- i Model in upright with wings folded
- ii Model lying on its side with wings folded
- iii Model upright with wings outstretched

Based on the results of the above three experiments, a fourth one was conducted to test the dispersal effectiveness over a long period of time. This was done by placing three models (upright lying on their side with wings folded) in an area that consistantly had gulls loafing. Models were left in place for eight days and observations were made daily.

A control was made for the effect of human disturbance on the dispersal behavior of gulls. This was done by walking into the aggregation of gulls with no model. Time was recorded from the moment walking

towards the gulls began until the moment the gulls returned. This enabled us to differentiate between effect of the model and human disturbance.

Model/Sound Experiments

The Glaucous-winged Gull Distress call was tested for its effect on gulls in a breeding colony. The Distress call was played at 5 minute intervals for 15 seconds, the total experimental time being 30 minutes.

The number of birds in a prescribed area were recorded before and after each call. Time was also recorded from the moment the sound stimuli ceased to the moment the first bird returned. Two series of sound experiments were conducted. They are as follows:

> The Distress call consisted of a 15 sec. tape loop that was started at random spots on the tape loop.
>
> The Distress call consisted of different 15 second calls taken from a continuous recording.

The proportion of birds remaining after the call was determined.

A number of model experiments were conducted with models in different positions. The function of these experiments was to determine combination of models with sound to see if model types make any difference in keeping gulls away from a prescribed area. Experiments were run both with and without the Distress call. In each experiment where the Distress call was used, the call was played at 10 minute intervals for 15 seconds. In the experiments where no call was used observations were made on the same 10 minute interval. The number of birds in a prescribed area were recorded before and after the call or the placing of a model. Time was recorded from the moment the sound stimuli ceased to the moment the first bird returned.

The model experiments with an imitation fiberglass head, neck and wings mounted on a wooden body in the Upright posture are referred to as the "imitation model". The model with a real head, neck and wings mounted on a wooden body in the upright posture are referred to as the "real model". The taxidermy mount of a complete dead gull is referred to as the "real whole mount" and the fiberglass model of a complete dead gull is referred to as the "imitation whole mount".

The series of experiments conducted were as follows:

> One imitation model lying on its side was placed in territories and used with the Distress call until 20 experiments were recorded.

159

One real model lying on its side was placed in territories and used with the Distress call until 25 experiments were recorded.

Two models, both imitation and real, standing upright or lying down were placed in territories and used with the Distress call until 10 experiments were recorded.

Two models both imitation and real were either standing upright or lying down, were placed in territories and used with no Distress call until 10 experiments were recorded.

One real whole mount was placed in territories and used with the Distress call until 11 experiments were recorded.

One imitation whole mount was placed in territories and used with the Distress call until 11 experiments were recorded.

Dispersal Experiments

Dispersal experiments using models and Distress calls were conducted at the WNAS Sanitary Landfill. Data was collected on the behavior of birds subjected to models and Distress calls. Experiments consisted of a 15 second Distress call, played with an imitation and real models lying on their side and the imitation whole mount. The number of birds before and after the placing of models or the playing of the Distress call was noted. Time was recorded from the beginning of the sound stimuli to the moment the birds returned. Particular attention was given to how long the birds stayed away.

Habituation to Sound Stimuli

Experiments with the Glaucous-winged Gull Distress call played in a colony showed that when a 15 second call recorded on a tape loop was played repeatedly, habituation occurred rapidly (Figure I). After six repetitions of the calls on this loop, 5 minutes apart, 83% of the birds in a given area remained unaffected by the call. When a continuous recording was played for 15 seconds at 5 minute intervals habituation was not as apparent (Figure I). In this series the Distress call was different for each interval and depending on the nature of the call the response was different. The calls that contained high shrill shrieks were observed to be more effective in causing birds to fly than low intensity calls.

Dispersal Using Visual Stimuli

At Shemya AFB, Glaucous-winged Gulls continued to come to the Upper Lake following placement of two model gulls in an upright position (Figure II). However, the day after the models were placed, a fox knocked one of the models on its side. Following this incident no birds were seen at the lake until the models were removed two days later. During this time birds used the Middle Lake for drinking and washing, a lake which had not been used by the birds previous to the placement of the models at the Upper Lake. Also, during this time we frequently saw gulls fly over the Upper Lake without landing. Following removal of the models, birds were seen on the Upper Lake again within six hours.

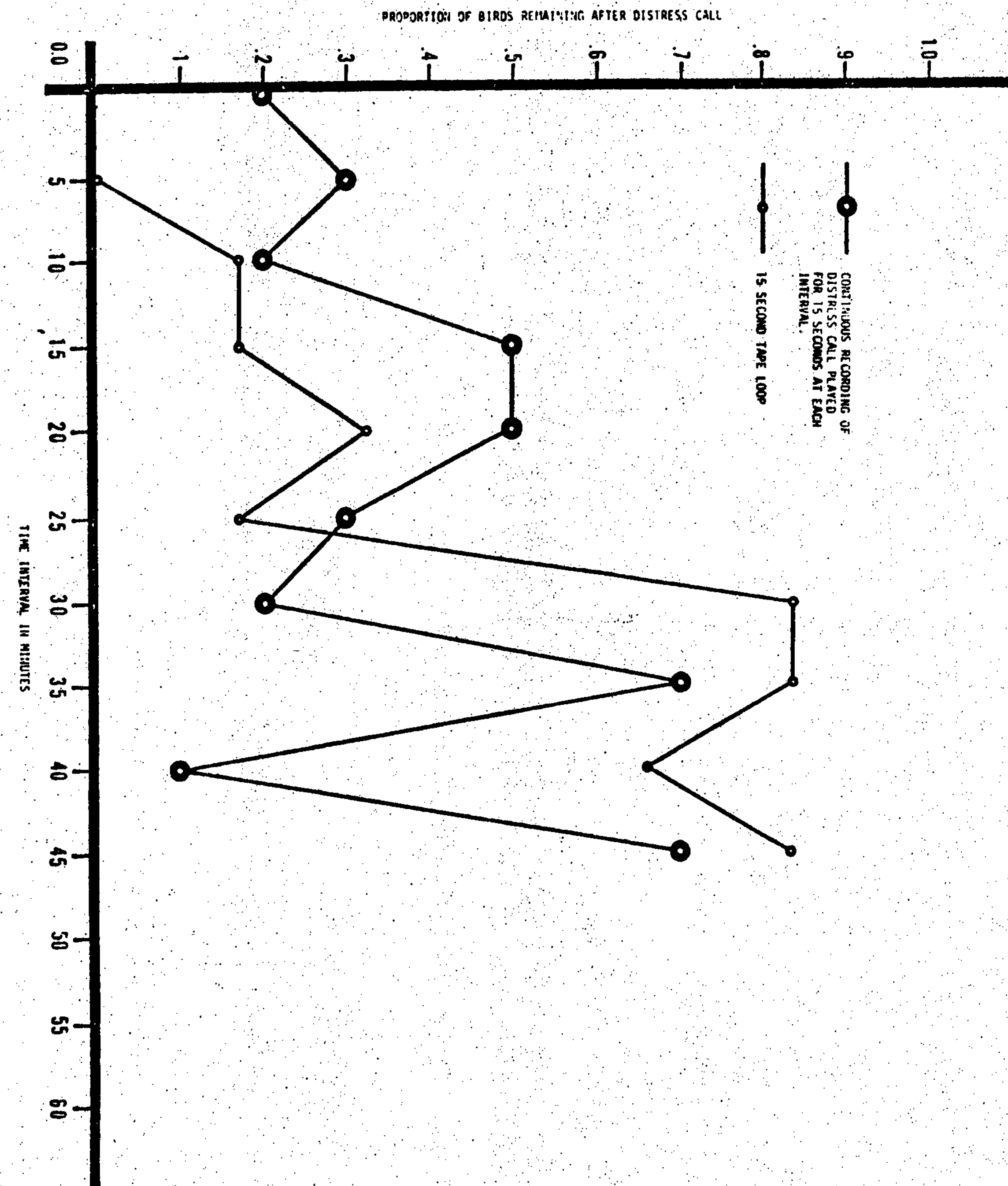
Table I summarizes the results of experiments with real models on the dispersal of Ring-billed Gulls from the vicinity of the Pasadena Sanitary Landfill near Ellington AFB. The models in the upright position with wings folded, proved least effective in causing gulls to disperse. Gulls readily returned near this model, but always remained 50 feet or so away.

The models on their sides with wings folded were effective in dispersing gulls for long periods of time (as long as eight days). The same was true for the model in the upright with wings outstretched. The effectiveness of this model appeared to be enhanced by wind blowing the primary feathers back and forth.

The typical response of the gulls to the models was similar to that observed to an injured or dying gull. Gulls would initially circle the models, sometimes in a dense mass. This would take place for two or three minutes with the circles becoming larger and larger. The gulls would then completely leave the area.

The control for the model experiments demonstrated that the reaction to the models was not the result of human disturbance as gulls returned almost immediately when disturbed by a human approaching their aggregations without placing gull models at the aggregation site. The experiment testing the effectiveness of models over long periods of time (eight days) indicated that as long as the models were present no gulls returned. Certain limitations were observed with the taxidermically mounted models. After extended periods of field use, the models began to deteriorate due to wet weather and insect infestation.

On one occasion approximately 750 gulls were observed loafing on the airfield at Ellington AFB. This large aggregation consisted of three groups situated at the beginning of runways 35, 17, and also 50 yards north of the center taxiway. Transit Alert attempted to disperse the gulls by driving their truck through aggregations only to find the gulls flew and quickly settled again close by. With the use of models and distress call playback, these gulls were cleared from the aerodrome within five minutes. It was shown that for the models to be effective they must first be visible to birds on the ground. It was therefore, necessary to raise the gulls off the ground



Graph showing the proportion of birds remaining after the Distress call is played at 5 minute intervals in a gull colony. Both the response to the 15 second tape loop and the continuous recording played for 15 seconds are plotted.

FIGURE I

162

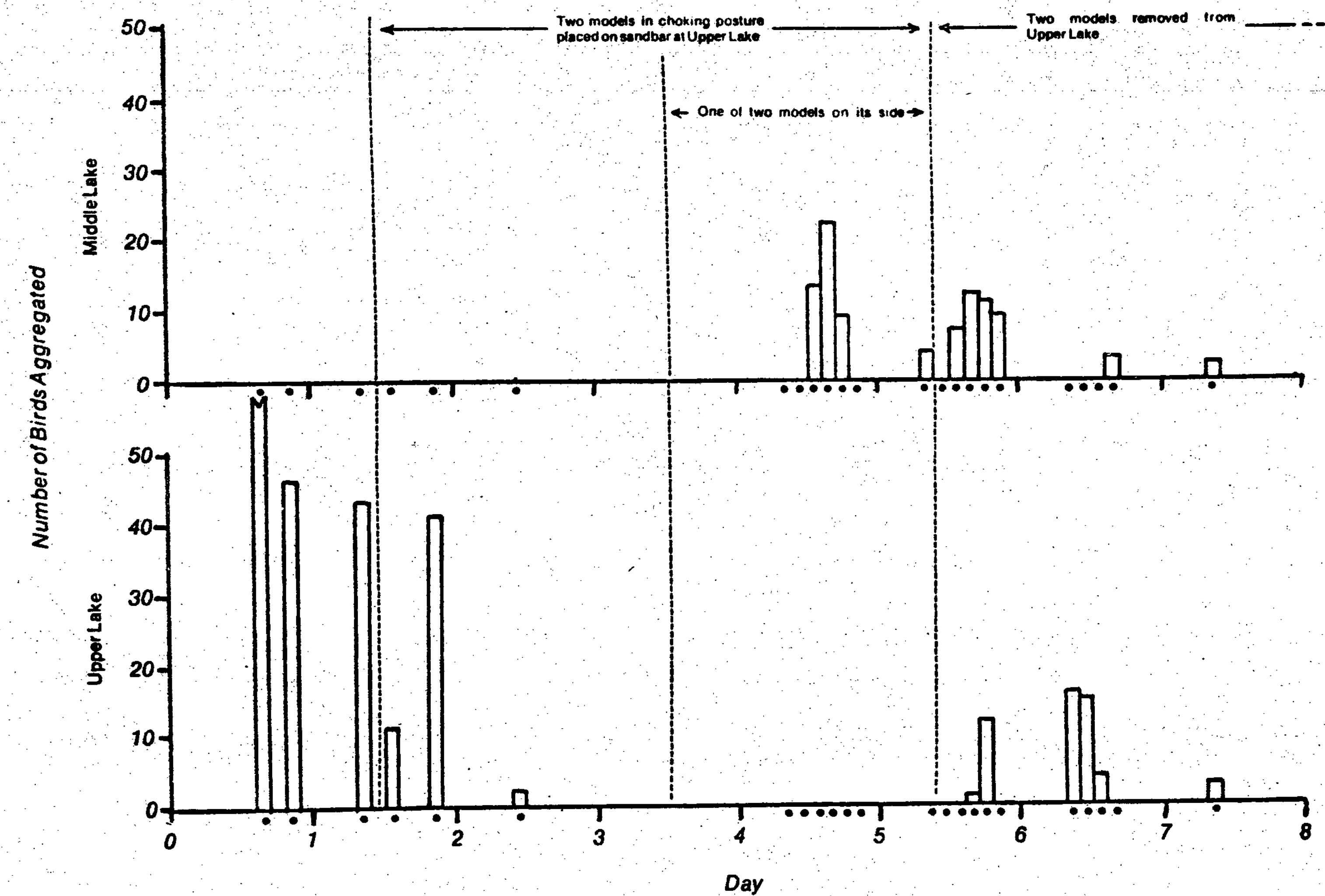


Figure II. Comparison of aggregations of the Glaucous-winged Gull (<u>Larus glaucescens</u>) on the Upper and Middle Lakes, Shemya Island, in response to two static models placed on a sandbar of the Upper Lake. The dots (.) below the x-axes denote times of observation.

163

TABLE I The dispersal effectiveness of models mounted in different positions for Ring-billed Gulls.

NUMBER OF BIRDS	NUMBER OF MODELS	TIME FIRST BIRDS RETURNED	LENGTH OF EXPERIMENT
i. Model upright with wings folded			
400	3	5 min	5 min
325	3	50 min	120 min
255	4	4 min	5 min
170	4	3 min	5 min
ii. Model on its side with wings folded			
125	3	-	200 min
175	3	*1 min	120 min
225	1	-	240 min
350	3	-	120 min
325	3	-	120 min
440	3	-	90 min
365	2	-	90 min
iii. Model upright with wings outstretched			
225	1	-	30 min
1,300	1	-	120 min
250	1	-	120 min
325	1	-	120 min
380	1	-	200 min

*Left after 30 seconds

with the Distress call. The gulls then from the air began to exhibit the typical behavior pattern of flocking over the models and leaving the entire area.

Dispersal Due to Model/Sound Experiments

The results of the model/sound experiments conducted in a breeding colony of Glaucous-winged Gulls are summarized in Table II. No distinct habituation was observed in these experiments in fact in many cases the reverse was found to be true. The imitation model on its side reinforced with the Distress call was demonstrated to have the least proportion of birds remaining after the call. The gulls however, returned fairly rapidly. In all the experiments involving models reinforced with the Distress calls the gulls that returned would not settle close to the models. In fact in many experiments there seemed as if an invisible fence was placed 5 feet around the model. In experiments involving just real models, the proportions of birds remaining after the call were the greatest.

The experiment involving a combination of models used with no Distress call was observed to have the shortest time for the first bird to return. When the Distress call was played back, it was observed that the mean time for the first bird to return was doubled indicating the effect of the Distress call. The experiments with the real and imitation whole mounts were shown to have consistently longer times for the first bird to return. The imitation whole mount with Distress call had not only the longest time for the first bird to return but also had a low proportion of birds remaining.

Dispersal Experiments at UNAS Sanitary Landfill

Table III sumarizes the results of experiments conducted at the WNAS Sanitary Landfill. Models reinforced with sound proved effective in keeping gulls away from certain areas. When models were placed close to a food source keeping gulls out for a long period of time was difficult. As soon as one gull landed the rest would soon follow. This was observed when both the imitation or the real models were present. In all cases gulls would not stay close to the models but would remain 5 feet or so away. The imitation whole mount was probably the most effective in preventing gulls from landing. No gulls were observed close to this model. It was noted that all the models must be visible at all times for maximum effectiveness.

The reaction of the gulls to the models was similar to that observed in previous studies. The gulls would initially circle the models with the circles becoming increasingly larger. After two or three minutes the gulls completely left the area. Gulls returning to the landfill would observe the models, fly low over them and land some distance away or in many cases leave the area entirely.

TABLE II

The results of experiments conducted to show the effect of different model/sound combinations in keeping Glaucous-winged gulls out of their territory.

EXPERIMENT	MEAN PROPORTION OF BIRDS REMAINING	S.D.	MEAN TIME FIRST BIRD RETURNED	S.D.
An Imitation Model on Its Side with Distress Call	.02	.08	21.1 seconds	13.79
A Real Model on Its Side with Distress Call	.13	.24	27.0 seconds	17.8
A Combination of Models with Distress Call	.12	.17	39.2 seconds	24.4
A Combination of Models with No Distress Call	.05	.06	19.4 seconds	9.8
Real Whole Mount with Distress Call	.16	.16	39.7 seconds	26.5
Imitation Whole Mount with Distress Call	.07	.11	53.0 seconds	27.5

TABLE III

The dispersal effectiveness of different models for Glaucous-winged Gulls

NUMBER OF BIRDS	NUMBER OF MODELS	TIME FIRST BIRD RETURNED	LENGHT OF EXPERIMENT
i Imitation Model Lying on Its Side			
50	2	20 minutes*	20 minutes
75	2	---	60 minutes
60	2	---	60 minutes
75	2	35 minutes *	35 minutes
30	2	---	60 minutes
ii Real Model Lying on Its Side			
50	2	20 minutes*	20 minutes
75	2	---	60 minutes
60	2	---	60 minutes
75	2	35 minutes*	35 minutes
30	2	---	60 minutes
iii Imitation Whole Mount			
75	1	---	120 minutes
40	1	---	60 minutes
25	1	---	60 minutes
50	1	---*	60 minutes

* Models were placed close to food source

167

Discussion

The possibility that habituation could eventually occur to Distress calls and the fact that these calls did not result in a permanent dispersal of gulls caused us to examine the results of the preliminary experiments with models at Shemya AFB with interest. Apparently, the gulls perceived the model on its side as a dead or injured gull and would not land in the area. Saul (1967) reported that crucified corpses of gulls tested at the Aukland International Airport, New Zealand, elicited similar responses from Black-headed Gulls (Larus dominicanus) and Red-billed Gulls (Larus novaehollandiae scopulinus).

The experiments conducted at the Pasadena City Landfill near Ellington AFB showed that models were definitely useful in dispersing gulls. Significantly, gull models mounted in an upright position with wings folded were not effective in dispersal. However, the models lying on their sides or upright with wings outstretched provided a stimulus that would disperse gulls. It was also significant that before a large aggregation of gulls on the ground would respond to the models placed on the airfield at Ellington AFB, they first had to be stimulated with the Distress call so that they could see the models from the air. This demonstrated the possibility that a combination of the Distress call played back with models may provide a more effective stimulus for dispersal than can be achieved using the Distress call or models alone.

However, the models were quickly deformed by the weather so tests were made with fiberglass as a molding agent. The addition of movement and/or sound to the models might further increase their effectiveness.

Habituation to the Distress call was observed to take place rapidly inside a gull colony (Figure I). A similar observation was made by Brown (1962) who experimented with the Distress call immediately outside a colony. In the non-colony situation, experiments made on Shemya AFB and Ellington AFB, indicated no noticeable habituation to the Distress call. It must therefore be important to distinguish between breeding birds in a colony and non-breeding gulls predicting the effectiveness of the Distress call in gull dispersal. Habituation was observed to be not as apparent in the colony when the calls were varied as with the continuous recording.

Models associated with Distress calls were observed to have no noticeable habituation in the colony (Table II). Upon hearing the Distress call the gulls would fly up and begin circling the models. The flight of most birds was not long and return to their territories took place rapidly. When the model or models were sighted by the gulls whose territory the models were in, the gulls would frequently continue circling periodically flying low over the model. When the gulls finally landed the birds would remain at the edge of the territory away from the models. The Distress call used with the model was always the same 15 second call. This same call, when used

/0

with no model was habituated too rapidly as cited above. It was apparent that the gulls must associate the Distress call with the model causing the absence of habituation.

The imitation model on its side with the Distress call was the most effective model/sound experiment causing the least proportion of birds remaining after the experiment (Table II). It was interesting to note that the gulls returned rapidly to following this experiment. The imitation model alone was not successful in keeping the gulls away. A combination of models which included both the real and imitation models placed side by side showed that the mean time for the first bird to return was greatly increased, and had the longest time for the first bird to return in all the wooden body model experiments. Without the Distress call the combination of models showed very short times for the first bird to return. This again indicates the importance of using the Distress call with models for maximum effectiveness.

Experiments were also conducted in a non-colony situation at the WNAS Sanitary Landfill (Table III). All the models were found to be effective in dispersal. It was noted however, that when large quantities of food were present the gulls would overcome the fear of the models and land close by. In no instances did the gulls stay close to the models but would always stay 5 or 6 feet away. In all cases of gulls returning, a single gull first took the initiative and landed, followed soon by others. A second burst of the Distress call however, would rapidly cause the birds to leave again. With the imitation whole mount no gulls were observed to return near the location of the model. It can be assumed that the imitation whole mount was the most effective model used in conjunction with the Distress call to cause gull dispersal.

The results presented in this paper clearly indicate that imitation model seagulls have been developed that are effective in gull dispersal. It was shown that there is a definite model sound association that substantiates the added effectiveness of having both sound and visual stimuli. Use of models may achieve a permanent dispersal of gulls from critical areas.

Literature Cited

1. Brown, R.G.B. 1962. "The reactions of gulls (Laridae) to distress calls". Annales des Epiphyties 13:153-155.

2. Saul, E.K. 1967. "Birds and aircraft: A Problem at Aukland's new International Airport". J. Royal Aeronautical Soc. 71:366-376.

3. Tinbergen, N. 1959 "Comparative studies of the behavior of gulls (Laridae): a progress report". Behaviour 15:1-70.

172

AD F 616 198

BIRD-STRIKE COMMITTEE BELGIUM

Lange Eikstraat 86

1970 WEZEMBEEK-OPPEM - BELGIUM

Tf BRUSSELS 216.21.50 - Ext 453

Telex BAFMETB 21764

BSCE/10 WP/9

SYNOPSIS OF THE ORGANISATION AND ACTIVITY
OF THE B.S.C. BELGIUM IN 1974-1975

1. A Belgian Bird Strike Committee has been installed in 1975,. Representatives of the Belgian Air Staff, of the Tactical H.Q., of the Training Group, of the Meteorological Wing, of the Radar Stations and civil ornithologists are members of this Committee. Chairman is Major W. LEMAIRE, Chief of the Meteo Wing. Delegates of this B.S.C. Belgium will continue to participate in B.S.C.E. activities as during the past.

2. In 1974 new maps and information concerning bird-hazards (concentrations and migrations) have been introduced for the BELGIUM military A.I.P.

3. Directives concerning vegetation-cultures and distress-methods have been issued and distributed for application to the authorities of all military airfield.

4. The investigations and experiments on Beauvechain airfield concerning the environmental vegetation and the presence of lapwings, carried out during 1973-1974-1975 are concluded in 1975. A report concerning this investigations is presented in annex A.

./.

5. A draft of a single European Bird movement/ bird concentration map has been issued within the framework of the Bird Movement Working Group of the B.S.C.E.
This map should have a scientific background and will be useful for pilots i.e. for low level flights;
Annex B represents the Belgian contribution to this map.

6. An experiment of electronic bird-counting is carried out by the Radar and Computer Center of SEMMERZAKE.
The aim of the project is to obtain by automatic electronic counting the up-to-date bird intensity at any moment and in any area within the RADAR-coverage. (using the B.S.C.E conventional 0 to 8 scale). A report concerning the programming of this Bird-counting experiment with a real-time computer is prescuted in annex C.

7. On some military-airfields a local birdpopulation study will be undertaken by establishing a synoptic daily bird-counting procedure and an environment investigation.

8. A special effort is made to obtain a more accurate identification of bird-species by bird-strikes.

APRIL 1975

J.K. BOOMANS

Senior Meteorologist

Meteorological Wing - Belgian Air Force

BIRD-STRIKE COMMITTEE BELGIUM
Lange Eikstraat 86
1970 - WEZEMBEEK-OPPEM - BELGIUM

Tf.: Brussels [illegible] Ext.: [illegible]
Telex.: [illegible]

ADF 616 199

BSCE/IO

Further Lapwing Investigations on Beauvechain Airport.

by J. Heirman, Centrum voor Bosbiologisch Onderzoek.

At the previous meeting of the BSCE, Mr. Louette reported about I973 investigations on Beauvechain Airport. The investigations included the establishment of long grass isles at both sides of the main runway, and a weekly record of the distribution of lapwings. Virtually no birds were seen in the treated part, except a few members of a minor group at the edge of the test zone. However, most lapwings were seen on farmland and not on grass. It was observed that they prefer some plots more than other ones, and it was suspected that they favour the same fields every year.

Therefore, to be sure about the effectiveness of the treatment, the experimental plots have been interchanged in I974. We maximalized the number of observations in order to obtain a continuous picture of the day to day variations, and to be able to point out possible influences of cultures and soil characteristics. We got the chance that last winter was very mild, so we had a very prolonged observation period, unlike in I973, when all lapwings were driven away by an early, abundant snow-fall.

The treatment itself has been simplified in so far that the isles have been replaced by alternating strips of short and long grass along the second runway. Each strip was I.80 m wide ; the length of the grass was about 70 cm at the end of the summer.

Results.

I. Fluctuations of numbers during the observation period.

The first peak seems to represent a regular migration wave. It is followed by a nomadic phase with irregular fluctuations (see App. A). These variations are not caused by movements between the airfield and the immediate surroundings, since peaks in- and outside the airfield coincide. There even exists a correlation with numbers of lapwings present at Zaventem National Airport (at 26 km). The whole curve seems to be the result of a superposition of different biological cycles (e.g. seasonal and lunar), influenced by meteorology. This yields complicated oscillations, which we are only just beginning to unravel.

2. Effectiveness of the long-grass strips (App. B).

The treatment seems to be effective in keeping birds away. The small number in the experiment of I973 was seen, in fact, in a partial blank. In I974, the experimental plot has been manured erroneously. This caused the grass being laid towards the end of the observation period. The diminishing of the screening effect might have been the reason that a few birds were on the plot in february '75. The advantage of our method is, that it is relatively simple. Besides, the strips of long and short grass could be mutually changed every year in order to maintain the grass in a good condition. In itself, however, the method is not sufficient to remove all lapwings out of the area, since most of them occur on tillage.

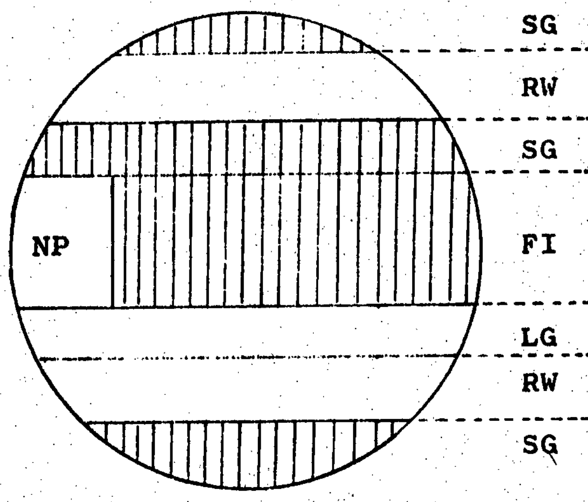
3. Plot-bound preferences.

Within the preferential grounds may exist some more or less favourable features that influence the choice by the birds, and even may cause their absence in a part of the plot.

fig. : Diagram of a preferential plot.

Lapwings were seen only in hatched parts.

SG short grass
RW runway
FI field
NP neglected pasture
LG long grass

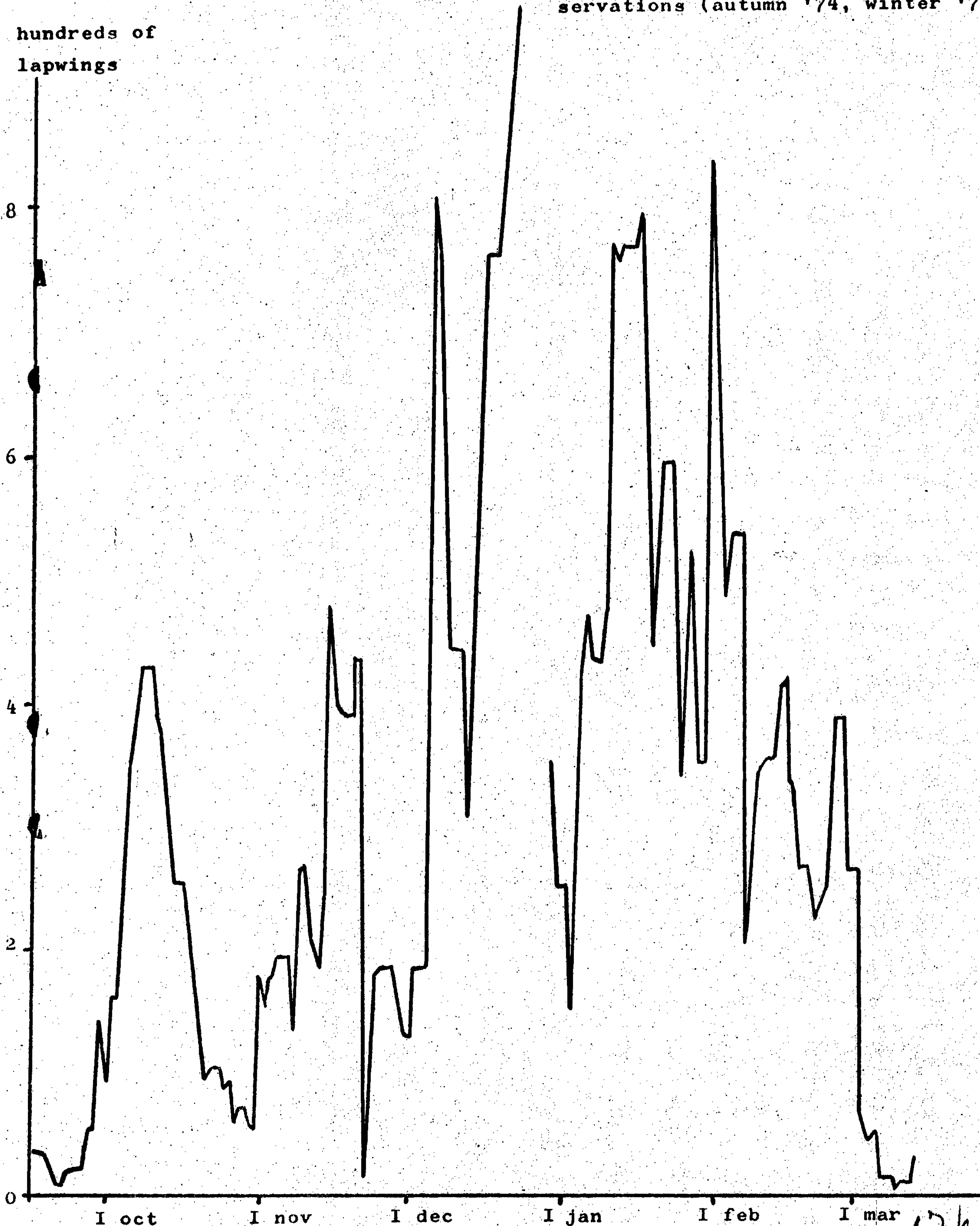


The preferences for different plots change with time and meteorology (e.g. temperature, precipitation). Thus the percentage of lapwings on grass roughly increases as autumn advances.

The general preference may be caused by soil characteristics. Most lapwings were found on imperfectly drained soils. Other soil characteristics may be important, but they have not yet been examined.

We could not detect a marked influence of different cultures upon the presence of lapwings after harvest. The only important thing here seems to be that sugar-beet keeps the field covered until late in the autumn. Growing sugar-beets might cause a drop in total numbers of lapwings, especially in early, severe winters.

App. A : Number of lapwings on Beauvechain airport : moving average of 7 days over 97 observations (autumn '74, winter '7



App. B : Long grass/short grass experiment. Number of lapwings per ha, per 10 observations, in the experimental plot (long grass isles in 1973, strips in '74-'75) and in the control (short grass, near second runway in '73, near main runway in '74-'75).

		experimental plot	control
1973	oct	0.00	52.94
	nov	0.65	0.00
1974-'75	nov	0.00	0.33
	dec	0.00	35.71
	jan	0.00	38.47
	feb	1.29	15.84
	mar	0.00	1.46

App. C : Number of lapwings (per ha, per 10 observations) on different soils, with indication of previous cultures for distinct plots. Drainage phases : b = well drained ; c = moderately well drained ; A = well to imperfectly drained (complex) ; D = moderately well to imperfectly drained (complex).

culture	plot nr.	b	c	A	D	UNKNOWN	ALL SOILS
Sugar-beet	1					3.89	3.89
	2					15.99	15.99
	Σ_{beet}					10.49	10.49
Beans	3	11.95					11.95
	4	59.60					59.60
	5		0.58				0.58
	Σ_{bean}	29.70	0.58				16.35
Cereals	6	0.99					0.99
	7		12.79				12.79
	8			18.35			18.35
	9				74.35		74.35
	10				14.18		14.18
	11					4.08	4.08
	12					2.79	2.79
	13					9.18	9.18
	14					0.00	0.00
	Σ_{cer}	0.99	12.79	18.35	22.35	2.25	11.37
$\Sigma_{cult.}$		16.45	4.07	18.35	22.35	6.06	12.69

BIRD-STRIKE COMMITTEE BELGIUM
Lange Eikstraat 36
1970 - WEZEMBEEK-OPPEM -BELGIUM

Tf.: Brussels 216.21.50 Ext.: 453
Telex.: BAFMETB 21764

BSCE/IO

A Belgian Birdstrike Risk Map based on numbers of birds to the unit of area.

by J. Heirman, Centrum voor Bosbiologisch Onderzoek.

At a small meeting of the Bird Movement Working Group on II/I2th of december I974 in Porz-Wahn, Belgian and German representatives agreed to draw up a simple European Birdstrike Risk Map with risk indications. This map should be based on objective criterions, to admit comparisons among countries.

3 types of risk were proposed :

Heavy risk area (hatched with red).

> I00000 birds cat. A + B + C/ I000 km²
or > 50000 birds cat. B + C/ I000 km²
or > 25000 birds cat. C/ I000 km²

Moderate risk area (hatched with green).

> 60000 birds cat. A + B + C/ I000 km²
or > 30000 birds cat. B + C/ I000 km²
or > I5000 birds cat. C/ I000 km²

Light risk area (hatched with blue).

< 60000 birds cat. A + B + C/ I000 km²
or < 30000 birds cat. B + C/ I000 km²
or < I5000 birds cat. C/ I000 km²

Birds of category A weigh 80 - 260 g,
" " " B " 26I - I000 g,
" " " C " > I000 g.

This paper reports about an attempt to make up such a map for Belgium.

138

1. Numbers of birds/1000 km² per province.

a. Basical data about bird populations.

We have at out disposition estimates per province, based on literature and counts, of the numbers of all regular breeders and winter visitors in Belgium (Lippens 1972). Actually the 'Koninklijk Belgisch Instituut voor Natuurwetenschappen' is working on a large-scale atlas project. This will be finished within 2 years and will furnish us a still more detailed information.
We judged homing pigeons should be included in the total bird population. The total number of registered homing pigeons in Belgium was 3.562.808 in 1972 (number of sold rings) ; at the end of the breeding period, there must be somewhat twice as much of them.
However, the estimated number of all other kinds of birds (> 80 g), breeding in Belgium, is 'only' 2.720.000 (x unknown factor at the end of the breeding period). This estimate may be too low, though proportions between different regions may be correct.

b. Conversion of bird numbers to the unit of area.

As a basis for comparison between the different regions, the estimated numbers of each species have been added up, and then converted in numbers of birds/1000km². Essentially terrestrial birds (e.g. galliformes) were excluded from the calculations.

Since smaller birds (cat. A & B) are the most common in our country, the highest classification was always obtained by additioning bird numbers of all weight categories. Breeding population is considered at the beginning of the breeding period; young are not taken into account.
The procedure yielded the following list (see next page).

One can see that the relative differences between the provinces remain roughly the same, whether the homing pigeons are included or not. We therefore decided to include them, though, as a consequence, relative importance of homing pigeons may be exaggerated.

Number of birds/1000 km² per province, all categories (> 80 g).

Province	Breeding population		Wintering population	
	Homing pigeons not included	h.p. included	Homing pigeons not included	h.p. included
O.-VL.	100.613	367.059	38.279	304.725
ANTW.	158.810	433.513	47.398	322.101
LIM.	107.414	218.525	21.959	133.959
LUIK	67.355	106.064	12.324	51.033
LUX.(G.D.)	69.855	72.595	13.173	15.874
LUX.(prov.)	70.466	72.721	11.146	13.401
NAM.	70.524	87.531	13.292	30.399
HEN.	69.767	165.497	13.316	109.046
BRA.	91.736	294.423	21.155	223.842
W.-VL.	74.130	218.219	91.531	235.620

Wintering populations in general were estimated lower than breeding ones, except in West-Vlaanderen (coastal region), but here again, relative differences between the provinces remain roughly the same. The figures on the enclosed Map I are those of the breeding population, except for West-Vlaanderen (it was agreed upon one should always take the highest classification).

2. Adjustments making allowance for hydrological and geomorphological characteristics.

Belgium can be divided roughly in 2 entirely different landscapes. North of the rivers Meuse, Sambre and Vesdre are found the alluvial or sandy lowlands and the loamy plio-pleistocene slope, south of them are situated the woody uplands of the Ardennes, which support a population of less than 100 birds/km², as is obvious from Map I. The high densities in Antwerpen (433,5/km²) and Oost-Vlaanderen (367/km²) are in part due to the presence of a lot of bird-rich ponds in Antwerpen (prov.), partly also to the fertility of the alluvium of the Scheldt. Densities here may be about 450 à 500/km², locally even more. The same holds for a narrow strip along the coast (West-Vlaanderen)

/5.

In the remaining part of the country one will find densities of about 200 à 300 birds/km². Based on this data, we drew up Map II. It was impossible to follow the proposed classification, because this would mean that 82,8 % of the Belgian territory would be heavy risk area. We therefore used the following provisional figures :

Heavy risk	:	> 350 birds/km² (all categories)
Moderate risk	:	100 - 350 birds/km² (")
Light risk	:	< 100 birds/km² (")

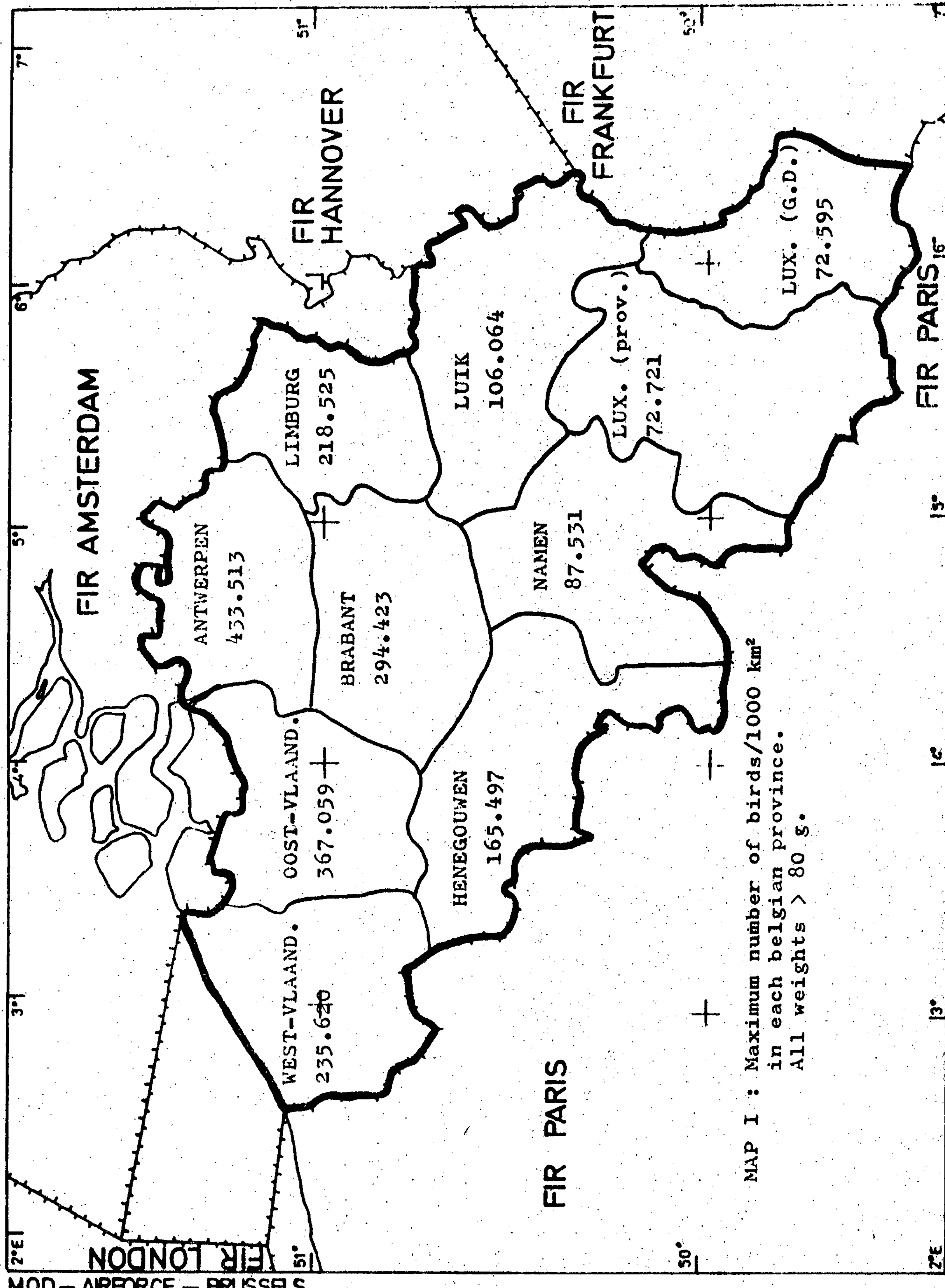
At least for Belgium, it would be possible to establish a more precise classification by using other colours, as usual in meteo. If the same could be done in other countries, a more useful map would be the result.

3. Small high risk areas.

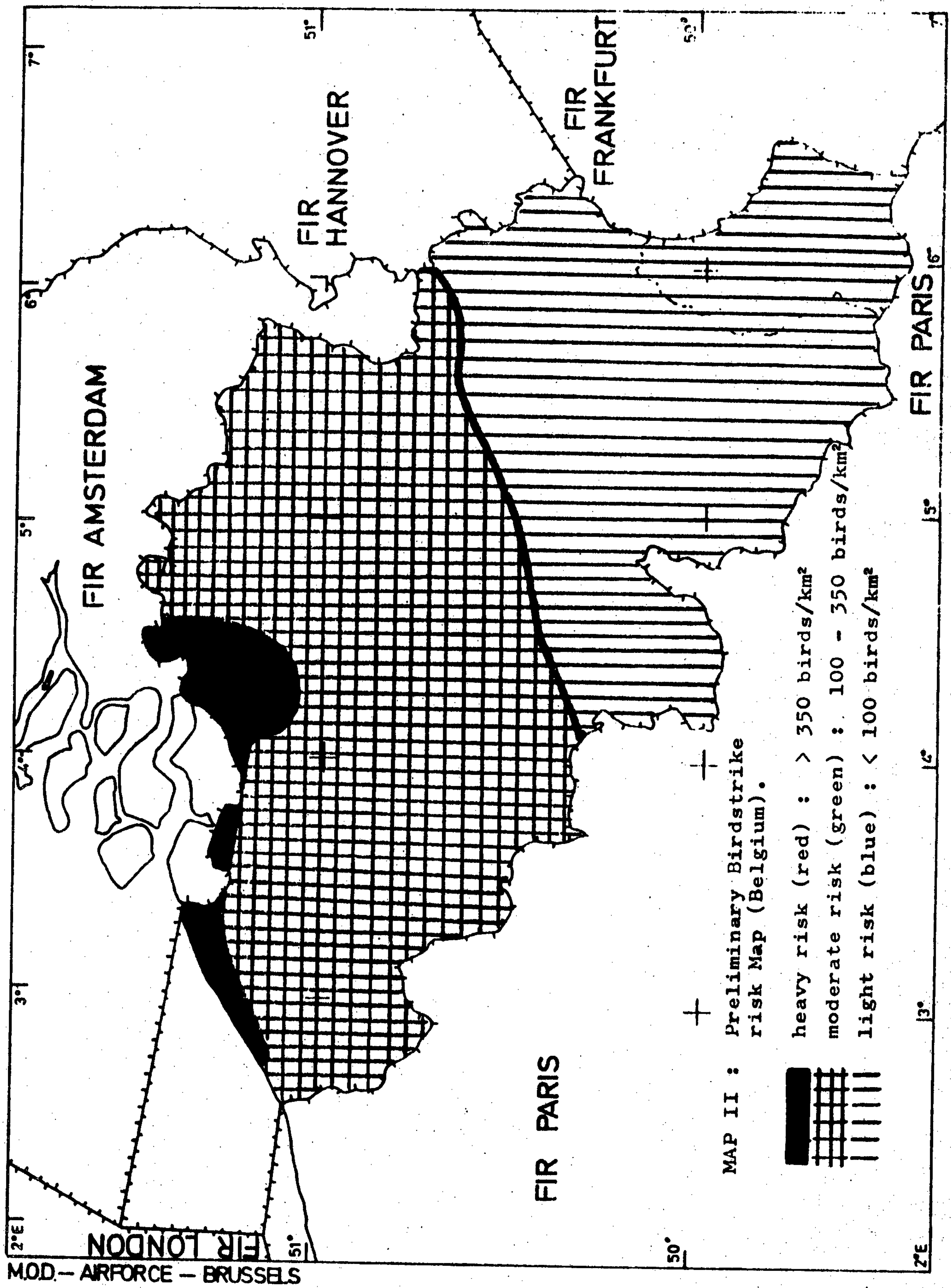
It was agreed that smaller areas with an exceedingly high birdstrike risk should be indicated on the map as red spots, and important bird conservation areas as red rings. Since this is not a major problem, they have been omitted here, for the sake of simplicity.

181

AIP MILITARY BELGIUM



MAP I : Maximum number of birds/1000 km²
in each belgian province.
All weights > 80 g.


FIR AMSTERDAM
FIR HANNOVER
FIR FRANKFURT
FIR PARIS
FIR PARIS
FIR LONDON
MAP II : Preliminary Birdstrike risk Map (Belgium).
heavy risk (red) : > 350 birds/km²
moderate risk (green) : 100 - 350 birds/km²
light risk (blue) : < 100 birds/km²
7°
6°
5°
4°
3°
2°E
51°
50°
M.O.D.— AIRFORCE — BRUSSELS

BIRD-STRIKE COMMITTEE BELGIUM
Lange Eikstraat 86
1970 -WEZEMBEEK-OPPEM -BELGIUM

Tf.: Brussels 216.21.50 Ext.: 453
Telex.: BAFMETER 21764

EXPERIMENTAL BIRD COUNTING WITH A REAL-TIME COMPUTER

1. The aim of the project is to inform the pilot and all interested agencies about the up-to-date bird intensity at any moment and in any area within the Radar-coverage. The intensity will be communicated using the 0 to 8 scale (B.S.C.E.-Convention).

   The hight-finder is available at the same radar-site.

   This can be done in the following way :

   a. Count the primary plots in a pre-planned sector.

   b. Find the relation between the number of primary plots in a sqaure kilometer and the intensity of the birds in this sector.
   This can be done by taking photos of the scope (mentionning time and date) during the counting (several months are needed to become valid results).

2. A solution has been searched in such a way that there are no disadvantages for ATC operations and no modifications of the existing equipment are needed.
   This solution is a pure software solution and consists of :

   a. A programchange in Radar Plot Reception. This change consists in extending the program. The purpose of the extension is the selection and the counting of the primary plots which are conform to the gate criteria, and the output of the result each radar revolution.

   b. A change in Keyboard program.
   The main purposes of this programchange are :
   -activate and stop the counting
   -imput of the gate via the rolling ball
   -calculate the surface of the gate

3. At this stage of the experiment it is possible to count the primary plots in a predefined area (which was determined by the rolling ball).
   The further devellopment is as follow :

   a. Calculate the surface of the imputted sector in which the plots are to be count

   b. Printing of the results on the operators concole each radar-revolution.

/ 1

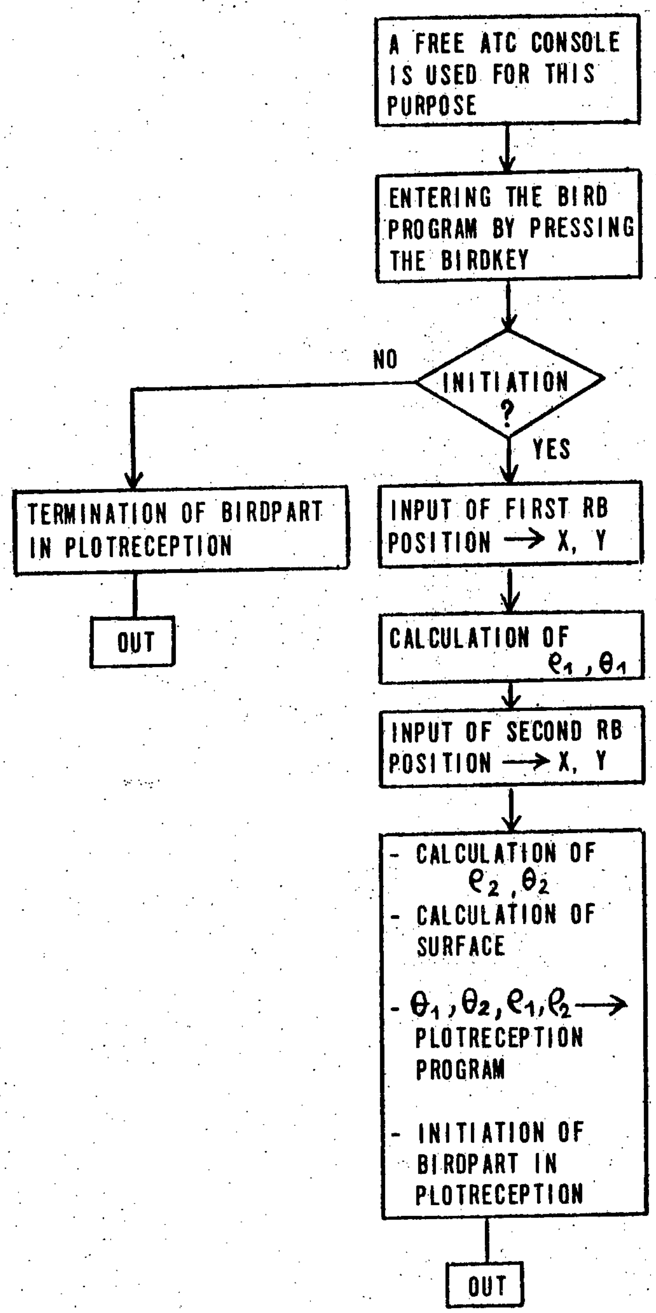
ADF 616 201

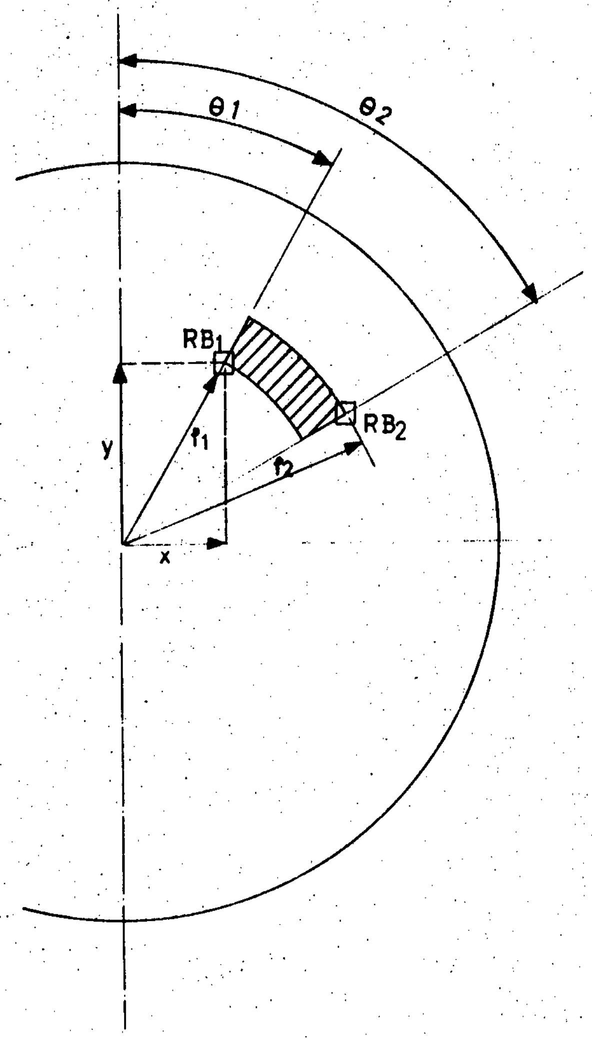
4. The execution of this program is possible at all concoles at the same time.
Normaly one console shall be used for this purpose.
The drawnings in annex will help to understand the working of the system.

C. SOETENS
Officer -Programmer
Lt v/h Vlw

185

INITIATION AND TERMINATION OF THE BIRDPROGRAM





□ RB : Rolling Ball

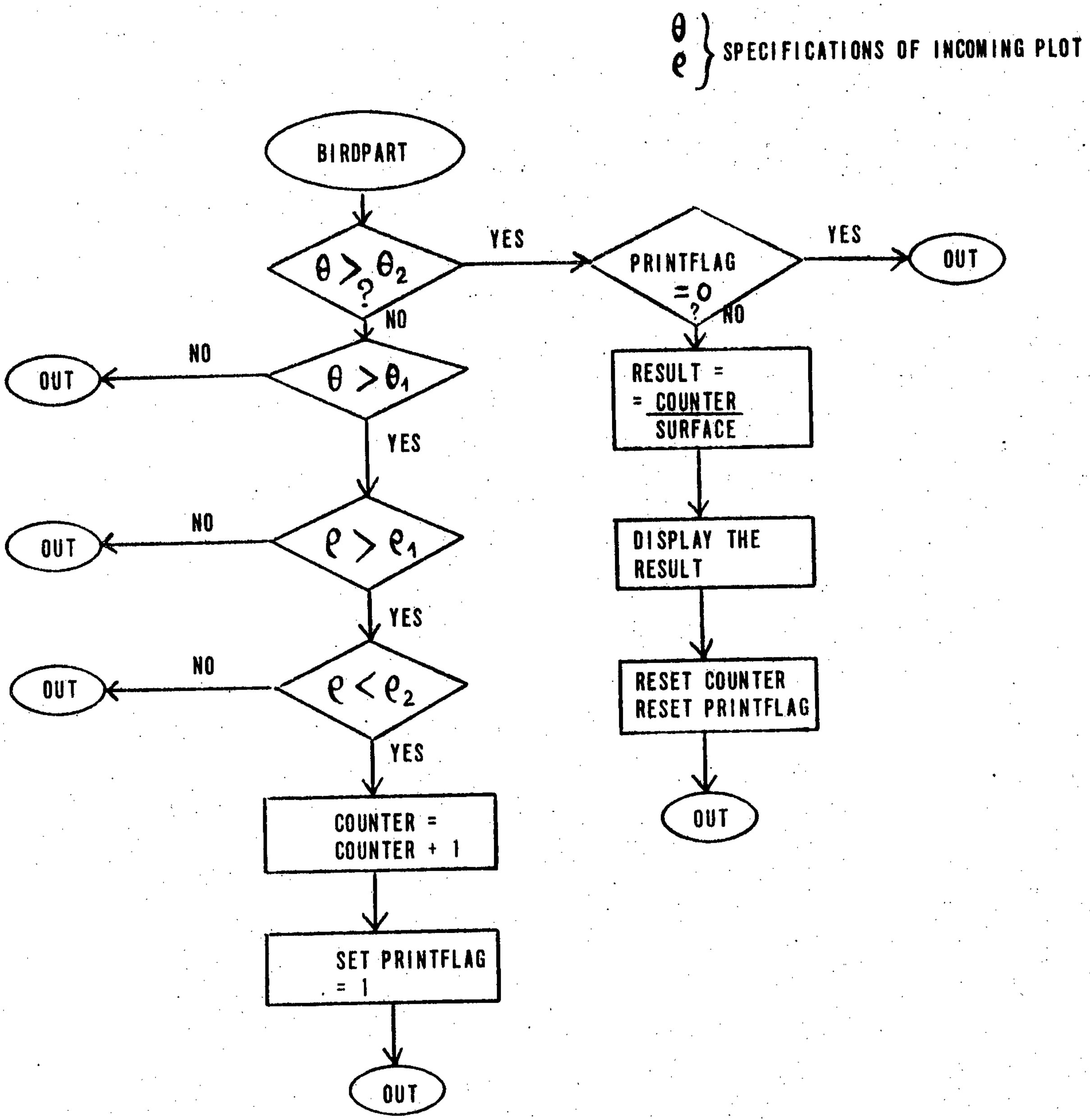
↳ Gives the X, Y position in relation to the radar station

$$\rho = \sqrt{X^2 + Y^2}$$

$$\theta = \text{arctg}\ \frac{Y}{X}$$

186

PLOTRECEPTION



THE BLACK-HEADED GULLS (LARUS RIDIBUNDUS) ARE ASSIGNED THEIR QUARTERS ON AIRFIELD

(M LATY)

In the Nice area, the black-headed gulls desert their see roost in bad weather. They take refuge at the Airport. At night they roost on the lighted parking areas. Even after the weather improves, they remain at the Airport for a few nights. This situation resulted in several serious accidents in the winter of 1973-74.

We have tried to keep the gulls away from the operational parts of the Airport: parking and traffic areas and runways. The traditional methods at our disposal proved to be ineffectual: attempts to frighten the birds away merely resulted in their milling about in the air above the Airport in large flocks.

Observing this, we decided to build a roosting area for the black-headed gulls at the Nice-Riviera Airport. Provided with conditions like those which seemed to attract them to the parking areas (shelter, light, safety, blacktop surface), they could spend their bad-weather nights there without endangering Airport flying conditions.

This novel idea was outlined at the 9th Meeting of the BIRD STRIKE COMMITTEE EUROPE. At that time, the roosting area had not been completed and was not entirely suited to the gulls' requirements. It was inadequately lighted and had not been blacktopped. No tangible results had not been achieved before the black-headed gulls left for their breeding grounds.

Since then, appropriations have been made by the General Secretaryship for Civil Aviation, and the Municipality and Chamber of Commerce and Industry of Nice.

The roosting area has been completed and was placed in service on January 16, 1975. The staff, including the Airport Manager, used their best efforts to persuade the black-headed gulls to spend their nights on the roosting area rather than elsewhere at the Airport in bad weather. Food scraps were spread over the roosting area and decoys were placed on the blacktopped surface lighted by floodlights. Concurrently, the operational parts of the Airport which were off-limits for gulls were made unattractive: the watchmen were given hunting rifles to shoot at the gulls, and efforts were made to frighten them away with distress calls. These deterrent methods had been used against the gulls before establishment of the roosting area. They had been ineffectual because the startled birds had had nowhere else to go. After the roosting area was built, positive results were obtained. The startled gulls took refuge there. However, it took 45 days for the birds to decide to roost on the area provided for them. This relatively long acclimation period may have been due to the difficulty of breaking the gulls of their habit of

spending their bad-weather nights on the lighted parts of the Airport, acquired before commissioning of the roosting area. Quicker results might have been achieved had the area been operational for the arrival of the first black-headed gulls wintering in the Nice-Riviera area. This hypothesis will be tested next winter.

The roosting area is described as follows:

Geographical location:

On the periphery of the Airport, bordering the Var River, inside a rental car parking area.

Surface area and soil cover:

5,133 square metres blacktopped, surrounded by a no man's land 25 metres wide. As an experiment, 460 square metres of the blacktopped area were covered with pebbles.

Lightning:

3 MAZDA P R M 1000 projectors equipped with Mac 1000 W Bulbs (130,000L) placed atop 12-metre poles 42 metres apart.

At ground level and horizontally, the yellowish-orange light intensity averages 10 luxes (21 measuring points). At a height of 1/2 metre and obliquely, it averages 31 luxes.

Lighting times:

From dusk to dawn. The lights are switched on and off by LUCIREX J H Y 4-lux Model 100 - 504 photoelectric automatic control.

Decoys:

15 plastic black-headed gulls were placed on the pebbled area. These were actually golden plover (pluvialis apricaria) decoys painted to look like gulls.

Feed:

10 to 15 kilograms of scraps from the Airport restaurant are spread periodically.

Construction and operating costs:

Ground surfacing:	63,000 francs
Electrical equipment:	45,000 francs
Annual power comsumption:	7,000 kWh (estimate)

Calendar of events:

Opening of the roosting area:	January 16, 1975
Spreading of food scraps:	February 28
First daytime sighting of gulls:	February 28
First nighttime sighting of gulls:	March 3
Last nighttime sighting of gulls:	March 31, 1975

No black-headed gulls were seen in the roosting area, day or night, in the period January 16 - February 28. They arrived promptly after spreading of food scraps. From and after March 3, the gulls sprent the night in the area in numbers varying with the state of the sea. 500 to 600 were seen in bad weather, very few in fine weather. As the end of winter was already approaching, and some of the gulls were leaving for their breeding grounds, it was impossible to make an accurate determination of the roosting area's attractiveness and accommodation capacity. We will endeavour to make such a determination next winter. Depending on the results, we might expand the roosting area.

CONCLUSION

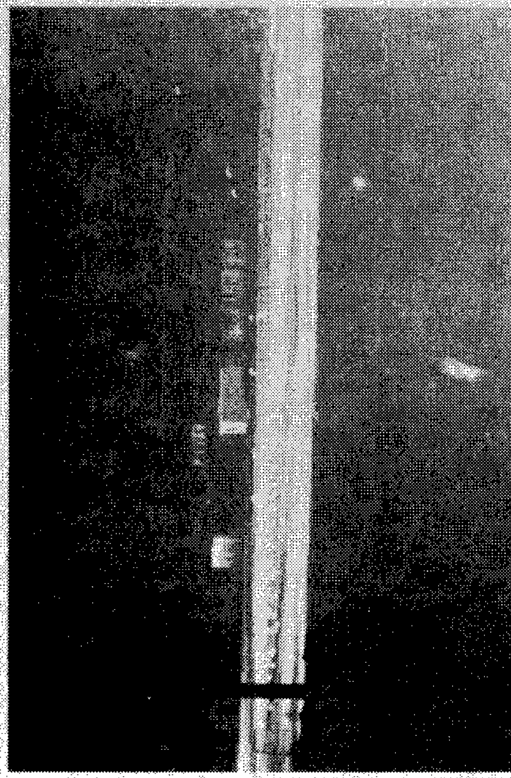
Positive results have been achieved: the gulls roosted on the roosting area provided for them, and air safety seems to have been improved accordingly. No collision with black-headed gulls occurred after opening of the roosting area. Although comparisons are premature, it can be noted that there were 7 collisions with black-headed gulls during the 6 months of wintering prior to the opening of the roosting area (January 1, 1974 - January 15, 1975). The 110,000 francs laid out may have been more than offset by the safeguarding of jet planes and human lives. How can profit in accident prevention be quantified?

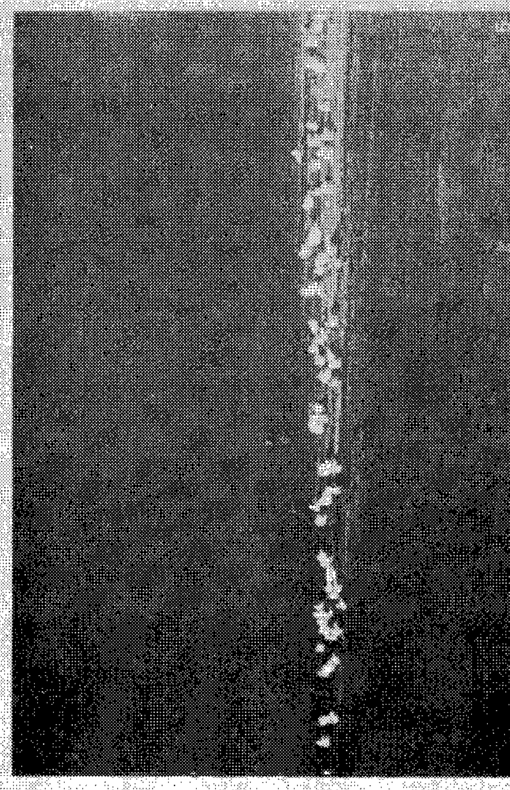
REFERENCES:

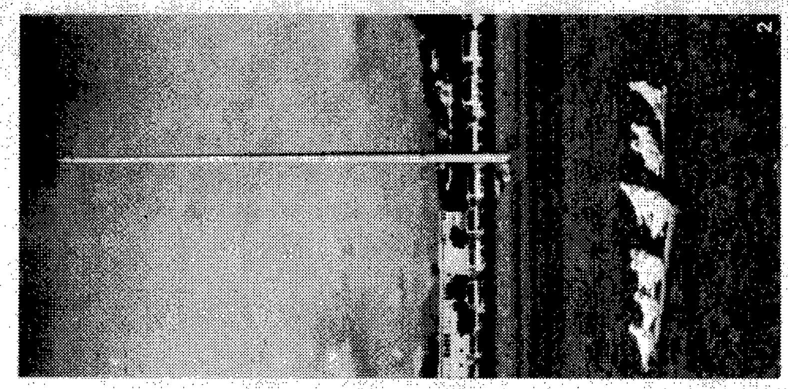
LATY M 1974 On the subject of the new risks of collision arising from the black-headed gulls at the Nice-Riviera Airport

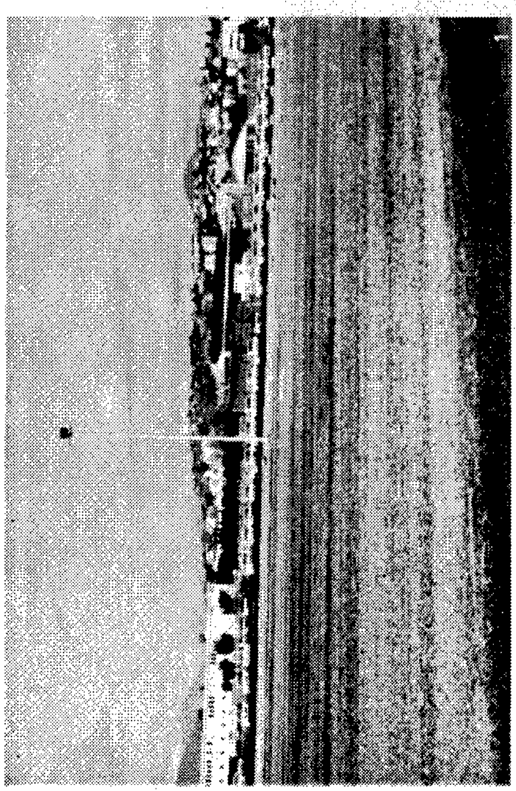
Proceedings, 9th Meeting, B.S.C.E. Frankfort - June 18-21, 1974

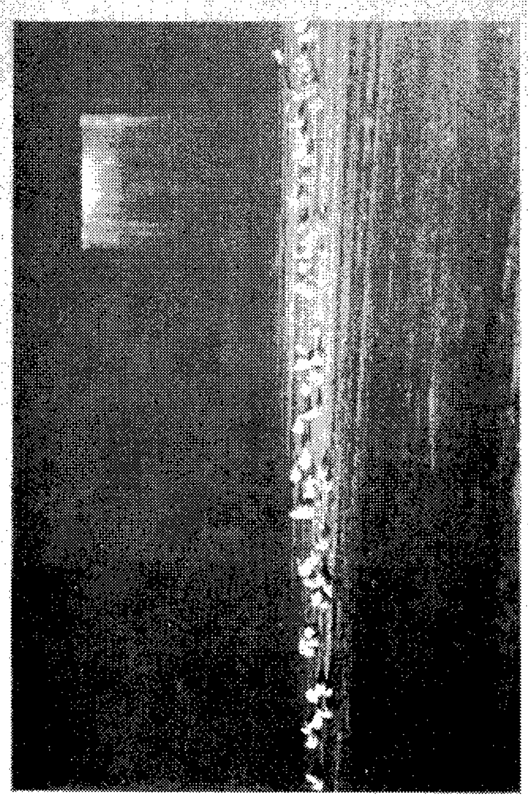
190











PREDICTIONS OF THE SPRING MIGRATION OF SNOW GEESE ACROSS THE TERMINAL CONTROL AREA OF WINNIPEG INTERNATIONAL AIRPORT.*

H. Blokpoel
Canadian Wildlife Service, Eastern Region Headquarters
Ottawa, Ontario

SUMMARY

1. The chronology of spring migration of Lesser Snow and Blue Geese (snow geese) in the vicinity of Winnipeg was determined, the influence of the weather was examined and the results were used to develop a method for predicting major flights (waves of migration).

2. Records of visual observations of migrating snow geese for the period 1953-69 were obtained from several sources.

3. Visual observations of staging geese during 1970, 1971, 1972 and 1974, confirmed that the majority of snow geese in southern Manitoba concentrated between Cartwright and Windygates, with the largest numbers near Pilot Mound, Crystal City and Snowflake.

4. In the springs of 1970, 1971, 1972 and 1974 time lapse films were made of the scope of the AASR-1 surveillance radar at Winnipeg International Airport. Visual observations confirmed that the great majority of "goose echoes" were caused by migrating flocks of snow geese.

5. Twelve (52%) of the 23 waves during the 1953-69 period occurred in or just ahead of a warm sector, near or on the east side of an occluded front, or on the west side of a high. The other waves occurred under a variety of synoptic weather conditions.

6. Direction and speed of the surface wind and precipitation

*Paper presented at the 10th Meeting of the Bird Strike Committee Europe held in Stockholm, Sweden, on 9-13 June, 1975.

at Pilot Mound, precipitation, direction and speed of the surface wind at Winnipeg, and direction of the geostrophic wind over Winnipeg were significantly related to the progression of the migration season.

7. These nine weather factors were used in a simple model to predict waves of spring snow goose migration for 1970, 1971 and 1972.

8. All predictions were based on weather reports rather than weather forecasts. Predictions for 1970 were checked against the 1970 radar data. Weather factors that caused large errors in the predictions were omitted or modified, and the revised model was used on the 1971 data. The model was further revised and used on the 1972 data. The following five weather factors appeared most useful for predicting spring migration: direction of surface wind and precipitation at Pilot Mound, and direction of surface wind and of geostrophic wind and precipitation at Winnipeg.

9. The accuracy of the migration predictions improved for each year and for 1972 85% of all hours of actual heavy migration were predicted, while 75% of all hours of predicted heavy migration materialized.

10. In 1974 this theoretical prediction model was used at Winnipeg International Airport to prepare operational migration predictions. Predictions were either "heavy migration" or "non-heavy migration". These predictions were based on weather forecasts (not on weather reports as was the case for 1970-72)

and were issued to Air Traffic Control each day at 0600, 1200 and 1800 hours. The overall accuracy of those predictions was 79%, but was much lower when only heavy migration was considered.

11. The accuracy of the prediction model for the spring 1974 migration was determined using weather records. Of the 49 hours of heavy migration, 38 hours (78%) were predicted while of the 72 hours of predicted heavy migration, 38 hours (53%) materialized. The accuracy of the prediction model for the spring migration of 1974 was lower than that for 1972.

12. Inherent shortcomings of the migration prediction model and difficulties in using the model with the terminology of weather forecasts make it advisable to revise the prediction model prior to further use. This revision would have to be preceeded by a new analysis of the data obtained so far using multi-variate statistics.

13. Operational usefulness of migration predictions for flight safety is limited because of the variability in the numbers and distribution of the migrating geese and in their response to weather changes. Even an improved migration prediction model with greater accuracy would only warn or alert pilots and air traffic controllers in a general way. A real-time operational system to prevent collisions during climb-out and descent would require additional information on the three-dimensional distribution of the bird flocks.

14. An automatic system, based largely on radar, would provide

//

information on all actual hazardous situations created by airborne birds of any species in sufficient detail to estimate bird strike probabilities. Further research and development work on such a "bird radar" is recommended.

DOCUMENTATION

Blokpoel, H. 1974. Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part 1: Distribution, chronology, directions, numbers, heights, and speeds. Can. Wildl. Serv. Rep. Ser. 28, 30p.

Blokpoel, H. and M.C. Gauthier. 1975. Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part 2: Influence of the weather and prediction of major flights. Can. Wildl. Serv. Rep. Ser. 32, 30p.*

Blokpoel, H. and M.C. Gauthier, 1973. Predictions of the 1974 spring Snow Goose migration at Winnipeg International Airport, Field Note 67, Associate Committee on Bird Hazards to Aircraft, National Research Council of Canada, Ottawa, 31p.*

Hunt, F.R. 1973. Probability of a bird strike on an aircraft. Field Note 62, Associate Committee on Bird Hazards to Aircraft, National Research Council of Canada, Ottawa.

Hunt, F.R. In preparation. Automatic radar equipment to determine bird strike probability. Part 1. Night-time land bird migration; Part II. Flock migration.

---

* Copies will be available at the meeting.

GLOBAL STATISTICAL APPROACH TO THE BIRD STRIKE

Henri Cesbron Lavau
Operational Research Group of the French Air Force

This paper has two purposes :

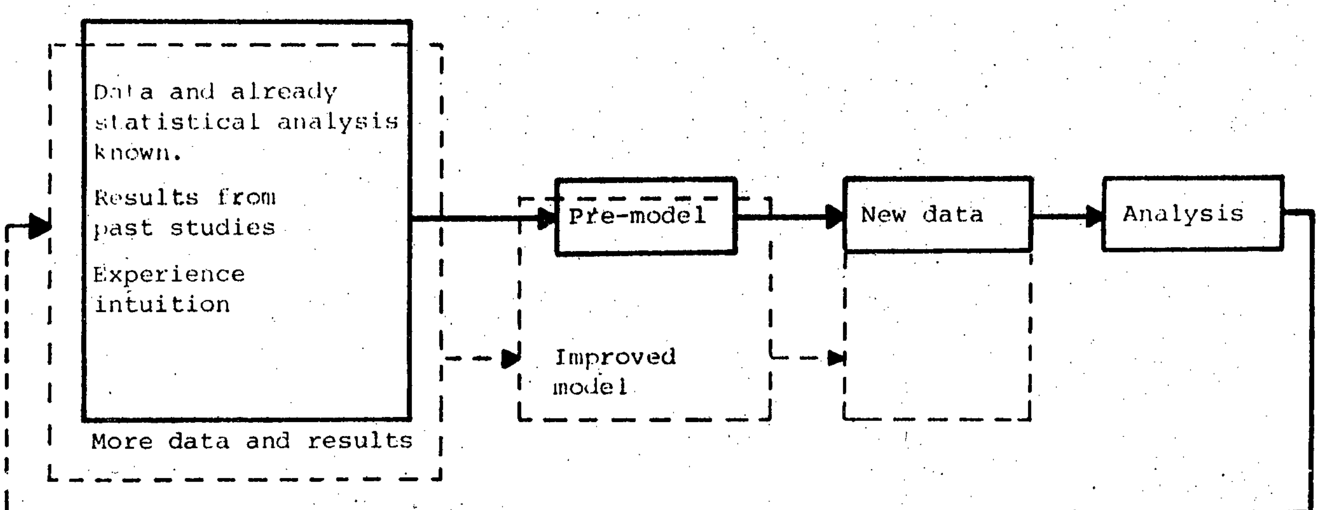
- to deal with a general model of bird strike and to bring up some statistical results from Bird Strike Report forms.

BUILDING THE MODEL

The model given in this part has as an only goal to organize the present knowledge - or unknowledge - of a bird strike.

The previous instrument is a preliminary model, a guide in collecting data. Swallowed and digested by the statistical computing system the data are synthesized to the different levels of interpretation.

The results are then helpfull to build a better model. According to the following schema, the model allows to go through the same steps more accurately :



.../...

Let us build now a pre-model

The input can be composed of :

- the time
- the localisation (including altitude)
- the meteorology (including visual distance)
- the "biotope"
- ... and so on ....

The output can be :

- the technical damage
- the drawbacks in planning
- the financial consequences
- the damage to personel
- ... and so on ....

without forgetting that not much from the bird is left.

The connection between input and output is now the delicate part of the model. Two types of connections may take place : the short term and the long term connections.

The short term connections are bound to the density of birds and of planes, the directions of flights, and the immediate reactions of the pilot to the bird (bound to the viability) and of the bird to the plane (bound to visibility and to the plane structure).

The long term connections are bound to time and places. Some information is collected by radars a little time before. More information concerning migrations is available a few weeks before. The information concerning local birds has been known for more time. All this data related to the probability of a strike. This probability depends also on the place defined by its geographical co-ordinates for the migrations and by

the biotope for all the migration and local birds.

The pre-model is more precisely developped in mathematical terms in appendix A.

It will be improved by any criticism and by the results of the analysis. It only use now is to give an answer to the question : which data is needed to verify what ?

GATHERING THE DATA

One has to collect the data needed to quantify the relationships proposed by the model.

One chooses a unit of time (the hour) and a unit of space (a square-mile per hundred feet hight).

DATA CONCERNING THE BIRDS

One needs a history of the densities of birds, for each spatial unit and each area .

This enormous mass of data can be reduced to manageable dimensions with the help of sampling and estimations techniques.

DATA CONCERNING THE PLANES

Similarly one needs the history of the activity of planes. One can limit oneself to simplify over space or time, if one selects the same times and spaces as for the birds.

DATA CONCERNING THE EFFECTS

This data is collected in the form of reports. One has to check especially the quality of the data related to the birds.

The remains of the birds are systematically examined by ornithologists. Besides, one could benefit from similar reports when the collisions were avoided by a manoeuvre of the pilot. Besides the extra-information one would get about the presence of birds at that spot at that time, one would find out complementary information about the local behaviour of the birds and about their reaction to the plane configuration.

.../..

ECOLOGICAL DATA

One needs to describe some other aspects of the location : possibilities of resting, of food and of nesting. The daily or seasonal habits of the birds should also be described.

2/10

FROM THEORY TO PRACTISE

All these considerations were made from the study of real data. Over a thousand of strikes have been coded, stored on a magnetic tape and analysed with the help of a UNIVAC 1108 computer. The programms used are written with FORTRAN and as they are of general interest in data management and global statistical analysis they are composed of more than 10 000 instructions. At the time when this paper was written, the results are just arriving. They will be presented at the Meeting. An append of more than ten pages results will be given. However, in order to prepare the interpretation of the results, we are going to see the form in which they will be given.

The datas are given by a form written by the pilot. An exemple is given in appendix B, 1121 forms have been feeled up between 1965 and 1973. The forms of last year are gathered and will be soon in the computer.

First, a univariate analysis will be given. As in appendix C, histograms will be given for each parameter. Some arrays will given to : And, concerning the localization, maps will be outlined by the computer.

But, secondly one should like to know if some variables have joint variations. The results will be given by multi-entry arrays. For example type of plane and location of the strike on the plane.

To analyze such an array, we are going to use the method of "analyse factorielle des correspondances" (1) which is described in appendix D.

---

(1) "L'analyse des données - Tome II" - Professeur Benzécri - Université de Paris - DUNOD - Paris - Brussels - Montréal.

It is enough to know that the results will be given on a plan. In the example above, there will be one point for each type of plane and one point for each location. And the types of plane near a point of location are correlated. Such a plan allows to see how the types of plane gather in groups, concerning the question of strike location. (See example in appendix D)

This will be done for any couple of paramaters which may have an influence one on the other.

CONCLUSIONS

By comparing among themselves the different results of the univariate analysis, one can bring to light some of the relationships underlined by the model.

By making use of the results of the "analyse factorielle", one can simplify the model by retaining only the significant variables.

Then one puts together the links between variables brought to light by the "analyse factorielle". Some aspects of the phenomenum may remain unexplained that we would like to include into our model. This can necessitate new data.

The model is the present summary of the present knowledge about the problem. That is to say, it is in everlasting evolution, especially when the subject is concerning the living world.

This evolution will be conduct in good condition when exist a narrow collaboration between ornithologists, pilots and operational research specialists.

- A P P E N D I X A -

Time and space are divided in small parts. Each part is homogeneus with respect to all the variables. For example the unit of time will be the hour, and the unit of space a square mile by one hundred feet.

The short term :

Let

$d_{p\,t_p}$ be the density of planes of type p (among n_p)

The density is defined as the average number of planes of type p per unit of time divided by the number of units of space contained in the considered area.

$d_{b\,t_b}$ be the density of birds of type b (among n_b)

Same définition as above.

$d_{s\,t_s}$ be the density of strikes of type s (place of the strike on the plane) (among n_b)

Same définition as above.

DP, DB and DS be the corresponding vectors.

$\mathcal{L}_P(DP)$, $\mathcal{L}_B(DB)$ and $\mathcal{L}_S(DS)$ be the corresponding probability laws.

$\mathbb{L}$ be the set of the statistical laws

$\mathbb{R}^n$ be the set of n couples or real numbers.

The model is then : $DS = F(DP, DB)$

where F is a vector function of two vectors : $\mathbb{R}^{np} \times \mathbb{R}^{nb} \xrightarrow{F} \mathbb{R}^{ns}$

or in terms of probability $\mathcal{L}_S(DS) = \mathbb{F}(DP, DB)$

where $\mathbb{F}$ is a mapping of the two forms vectors into the set of the statistical laws :

$$\mathbb{R}^{np} \times \mathbb{R}^{nb} \xrightarrow{\mathbb{F}} \mathbb{L}$$

If DP and DB are only forecasts, then the model takes the form :

$$\mathcal{L}_S(DS) = \mathcal{F}'(\mathcal{L}_P(DP), \mathcal{L}_B(DB))$$

where $\mathcal{F}'$ in a mapping of the set of couples of statistical laws into itself :

$$\mathbb{L} \times \mathbb{L} \xrightarrow{\mathcal{F}'} \mathbb{L}$$

Not only the densities have an effect on the probability of the strike.

The angle between the flight direction of the bird and the plane, and the immediate reactions of the pilot to the bird and the bird to the plane have also an effect.

Let

θ be the angle between the flight direction of bird and the plane

P be the immediate reaction of the pilot to the bird (which so far is a two state variable : avoidance manoeuvre took place or did not take place).

.../...

204

$\mathcal{B}$ be the probability law of the locus of the strike given a type of bird and a type of plane.

The general form is then :

$$\mathcal{L}_S(DS) = \mathcal{F}'\left(\mathcal{L}_P(DP), \mathcal{L}_B(DB), \Theta, P, \mathcal{B}\right)$$

THE LONG-TERM APPROACH

Some bird density configurations may be projected in advance : either, exactly, some hours (time t_1) before, following some radar observations $\mathcal{O}(t_1)$ for instance, either roughly, weeks in advance (time t_2) (Migratory movements or local movements with same regularity :$\mathcal{O}$ (t_2)).

More generally, some information on daily or seasonal movements will be known for all year long : $\mathcal{O}$ (t_3).

The location configuration, defined either by its geographical coordinates G , or by a set of variables pertaining to the environment E also is to be taken into account.

$\mathcal{O}$ (t_i) refers to the set of time information known at time t_i.

G or E define the location.

The model then becomes :

$$DB = F\left(G \text{ or } E, \ldots \mathcal{O}(t_i) \ldots\right)$$

or better

$$\mathcal{L}_B(DB) = \mathbb{F}\left(G \text{ or } E, \ldots \mathcal{O}(t_i) \ldots\right)$$

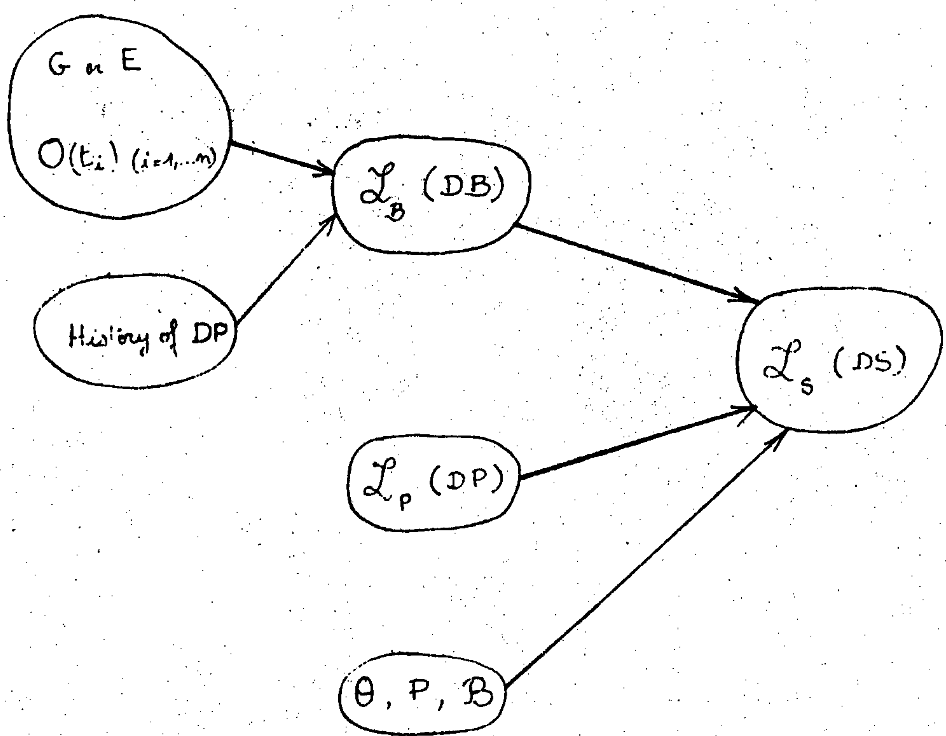
with $\mathcal{L}_B$ probability law of DB .

It is quite possible that the density of planes has an influence on the presence of birds (influence of DP or DB).

This is called the reaction of birds to the milieu.

.../...

Before any verification, the model is presented as follows :



REPUBLIQUE FRANCAISE
Ministère des Transports
SECRETARIAT GENERAL A L'AVIATION CIVILE
Service Technique de la Navigation Aérienne

Appendix B

APPENDIX B
FICHE de compte rendu
de rencontre d'oiseaux
(avec ou sans impact)

Le [illegible] 19[illegible] à [illegible] heures EXPLOITANT : [illegible]

TYPE DE L'AERONEF : [redacted] [illegible] [redacted] Immatriculation : [redacted]

REACT.	X
TURBO.	
CONVENT.	X

TYPE d'INSTALLATION MOTRICE : *

LIEU GEOGRAPHIQUE de l'INCIDENT : [illegible]
[illegible] HC 22 /17

ALTITUDE : 0 * mètres X / * feet — VITESSE : [illegible] * Kts X / * Km/h

* LIEU		* PHASE DE VOL AU MOMENT DE L'INCIDENT			* CONDITIONS DE VOL		* CONDITIONS ATMOSPHERIQUES	
FIR Nord		Roulement au sol	1		I F R		Ciel clair	
FIR Sud-Est		Décollage	2	X	V F R		Nuageux 5/8	X
F I R Sud-Ouest		Montée	3		I M C		Couvert	
Côtes	X	Croisière basse	4		V M C	X	Pluie	
Etranger		Croisière haute	5				Neige	
		Attente	6		NUAGES : Au-dessus		Brouillard	
		Descente	7		Dans		Jour	X
		Approche	8		Au-dessous	X	Nuit	
		Atterrissage	9		Entre		Aube	
		Inconnue	0		Givrage		Crépuscule	

* PARTIE HEURTEE : [illegible]
GMP | Cellule | Verres Charges | Equip Nav Rad | Train

* INFRA : Voiture | Pistolet | HP | Faucon | Chasse

OISEAUX Espèces / [illegible] mouette
Petit | Moyen | Gros | Isolé | Volée

* DOMMAGES : Important ☐
Appréciable ☐

* Blessés | Tués | Dégats aux tiers | Modif PLN | Changt moteur | Mise HS

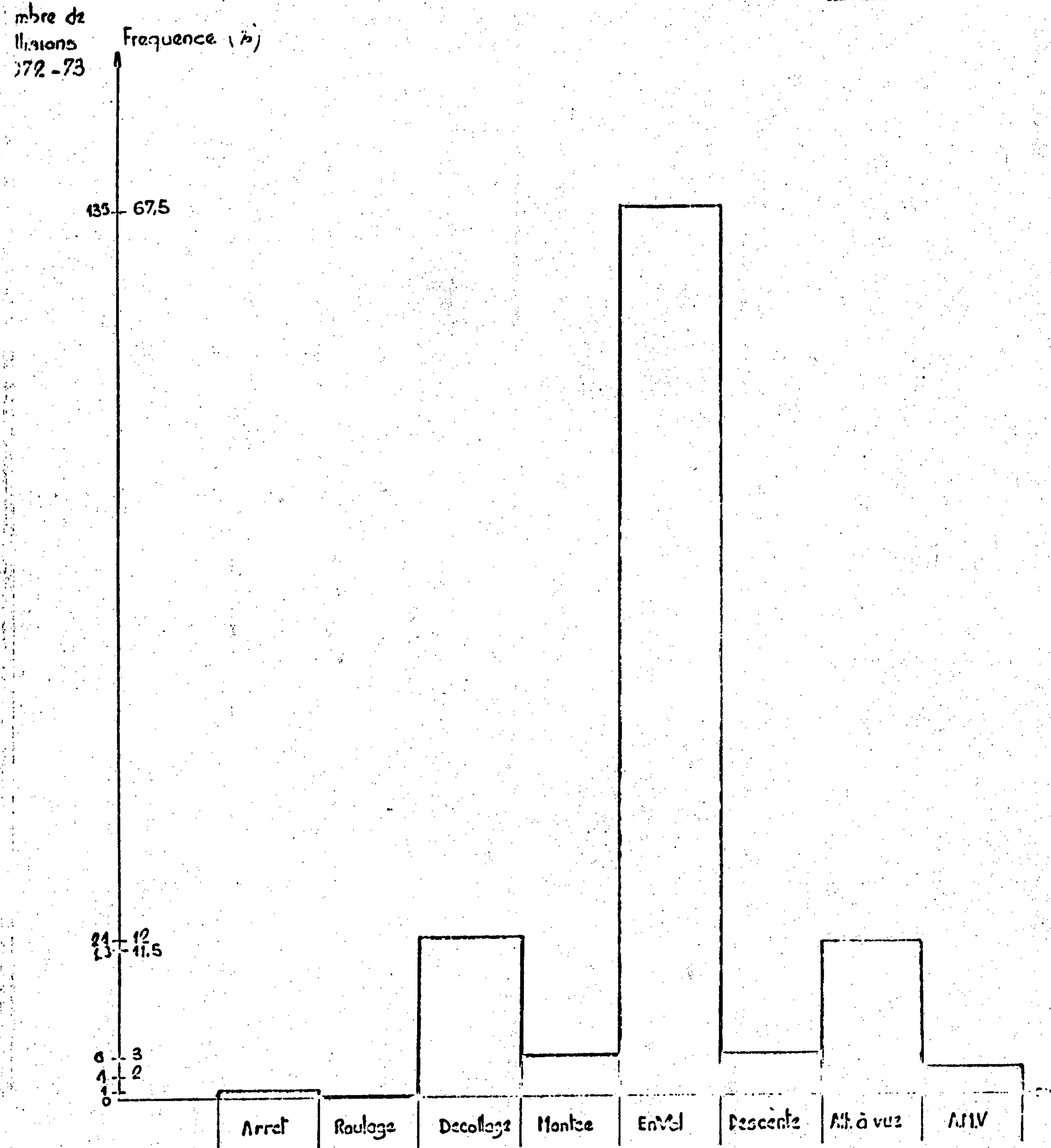
* MONTANT DU DEVIS ESTIMATIF en $ ____

* Observations oiseaux par pilote	
* Y-a-t-il eu avertissement de l'ATC	
* Y-a-t-il eu manoeuvre d'évitement	
* Observations impact par pilote	
* Impact	
* Arrêt moteur : VOLONTAIRE	
INVOLONTAIRE	

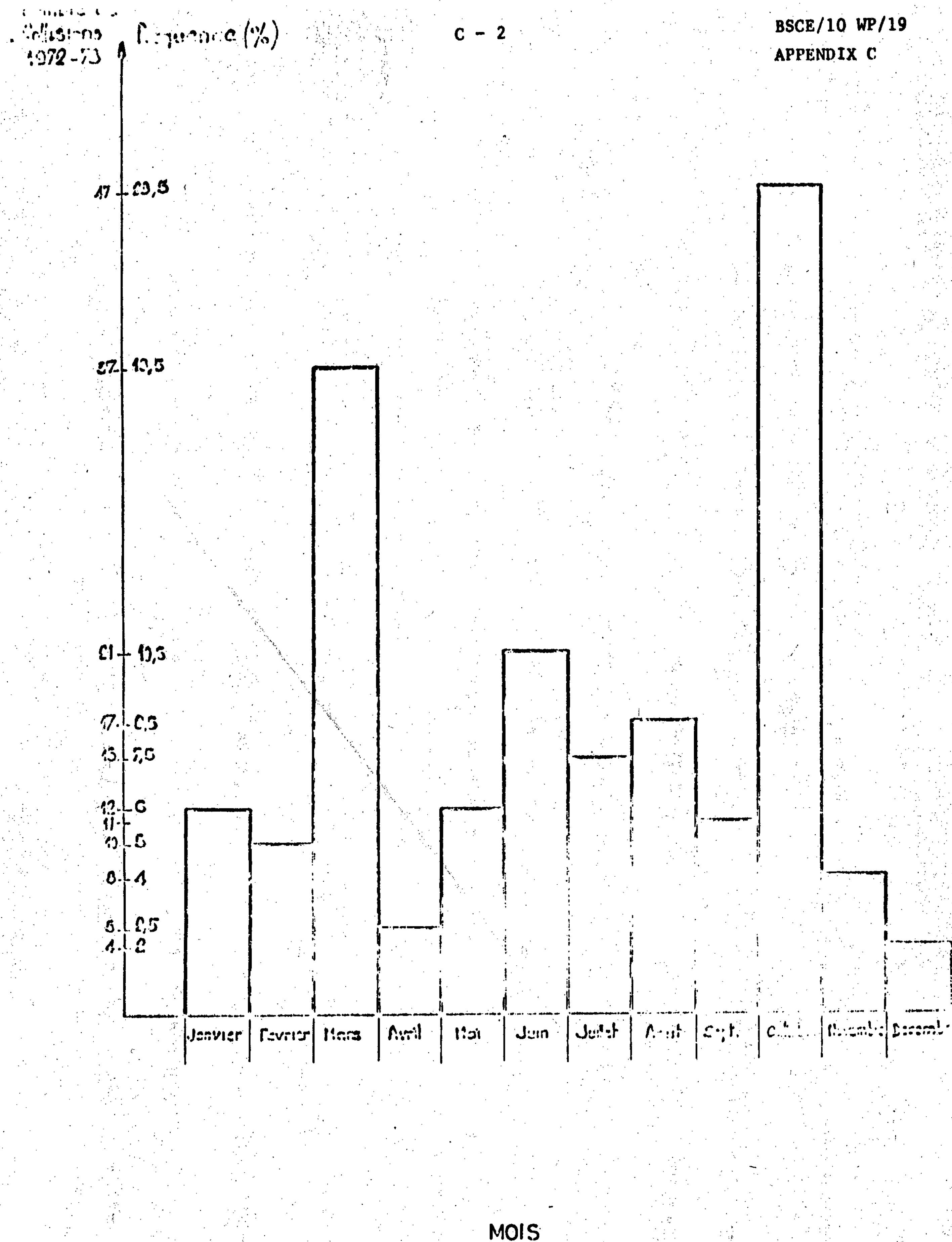
* G M P			* CELLULE		
Réacteur N° 1 G	1		Voilure	1	
Réacteur N° 2 G	2		Fuselage	2	X
Réacteur N° 3 D	3		Habitacle - Portes verrières - Hublots	3	X
Réacteur N° 4 D	4		Gouvernes	4	
Réacteur Central	5		Divers	5	
Hélice	6			6	
Entrée d'air	7			7	
Saumon de pale	8			8	
	9			9	
	0			0	

CAS PARTICULIERS :
OBSERVATIONS : [illegible] sur la [illegible]
[illegible]

Compte rendu rédigé par : [redacted] [illegible]



PHASE PRINCIPALE DE VOL


Janvier
Avril
Juin
MOIS

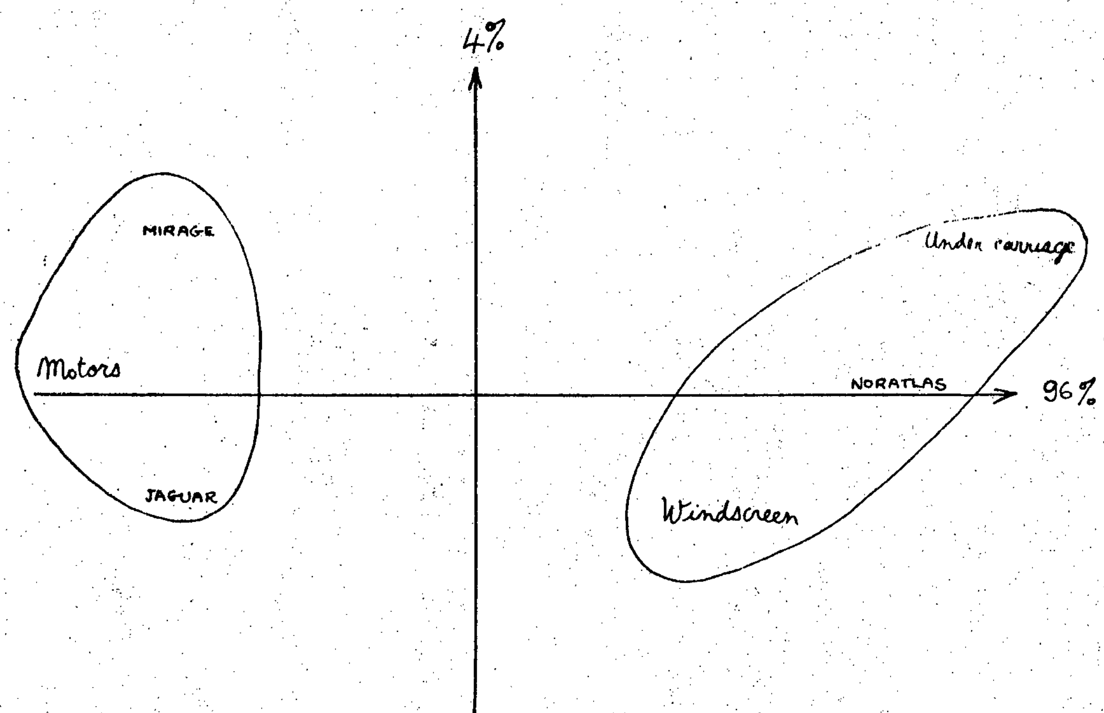
- A P P E N D I X D -

In order to enable to analyze the results presented by the "Analyse Factorielle des Correspondances", here is an example.

The multi-entry array for type of plane and location of strike on the plane may be the following one :

	Windscreen	Motors	Under-carriage
NORATLAS	45	26	67
JAGUAR	24	56	10
MIRAGE	15	60	17

This array may be represented on a plan.



On the plan, the Mirage and the Jaguar are near the motors because in the array most of the strikes for these two planes are on the motors. On the other hand, the Noratlas is near Under-carriage and Windscreen and for from Motors.

This plan where the links between two types of variables (plane, place of strike) are analyses is obtained by the following mean.

Let us consider the three lines :

- Noratlas (45,26,67)
- Jaguar (24,56,10)
- Mirage (15,60,17)

as the coordinates in R^3 of 3 points.

These 3 points determine a plan.

On the other hand, we can do the same with the three columns :

- Windscreen (45,24,15)
- Motors (26,56,60)
- Under-carriage (67,10,17)

are the coordinates in R^3 of 3 points.

These 3 points determine usually another plan. But the theory gives a mean to obtain the same plan. (This plan is defined by the two first eigen-values of the covariance matrix - see BENZECRI).

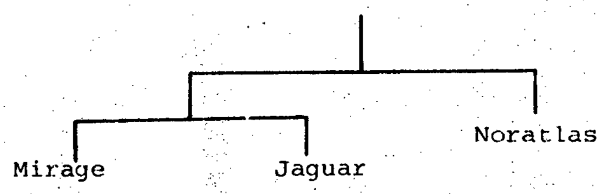
On this plan, the theory says that a line, the Mirage for instance, is placed at the center of gravity of the 3 locations of strike, when each one takes the weight given by the array. (15 for windscreen, 60 for Motors, 17 for Under-carriage). The same property exist for the other planes : Mirages and Jaguar are not very far because the relative weights are nearly the same.

.../...

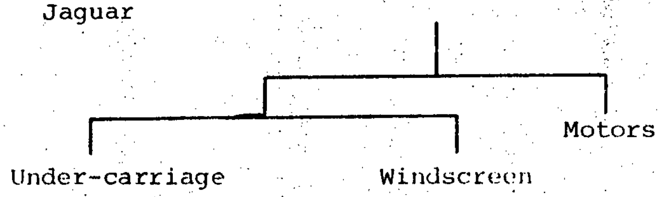
The relationships between planes and places of strike appears more clearly.

In this example, the array is small and a quick recognition is possible on the figures. But in big arrays, it is more difficult, at least impossible to see the links in the array. The preceeding method an be used. Except that in general, many points are not on a plan. In this case, the theory (and computer) give the plan on which the projection of the points are the more spread. In otherwords, it is the plan on which the projections are still grouped in the way the corresponding points are in the space. The percentage of information kept is given by the two first eigen-values of the covariance matrix.

When this percentage is low (under 50 %) the groups of projections do not reflect very well the groups of points. A hierarchical taxonomy will give us the groups. In the preceeding example we would have



and



The groups appear clearly.

Most of the results will appear in this form. This example is here, in order to help their reading.

STUDIES OF BIRDREACTIONS, CAUSED WHEN EXPOSED TO LASER LIGHT

L. STÅHL & S. JOHANSSON

ABSTRACT

The presentation will be composed by the following points:

1. The birds sense of sight and range of sight
2. Pilot´s possibilities to use light in order to avoid birdstrike
3. Disadvantage of ordinary taxi- and landinglight
4. Advantage of laser-light
5. Studies of birdreactions, caused when exposed to laser-light
6. Modified methods for future experiments
7. Technical facts

Birdstrike prevention success and malaise in the RNLAF

(abstract)

L.S. Buurma

Royal Netherlands Air Force

1. The Netherlands because of its geographical situation is a delta area very rich in birds and situated at the crossing of bird migration routes. The birdstrike ratio is therefore very high, which is why it is not surprising that the Royal Netherlands Air Force soon after the introduction of ever faster flying aircraft resulting in exponentially increasing damage undertook an investigation into preventive possibilities. After a number of productive years, also in BSCE context, a gradual decrease in alertness and zest set in due to the wide-spread disbelief in preventive measures, particularly in bird migration warnings. A number of main causes underlie this decrease, namely:

   a. Flight restrictions are in conflict with operational interests; so they must be wel founded for the pilot to accept and believe them. An initial unwillingness must be overcome;

   b. The effectiveness of preventive measures can only be measured on the basis of statistics and at a longer term. The conclusive force is weakened by the absence of a similar situation without prevention which might serve as reference, and by the fact that military safety officials, types of aircraft and conditions change continually;

   c. Impatience caused by the fact that more often than not evidence is received too late promotes the tendency not to keep up the statistics (reporting of strikes without any damage reflect the biologist's activity). All this especially hampers the argumentation;

d. There is no -

./..

d. There is no time to establish a relation of confidence between the man who issues the restrictions and the one who has to comply with them, because the former always is a conscript (an ensign who does his military service) instead of a regular ornithologist.

2. The RNLAF birdstrikes have been analysed once again, also on the basis of results of an analysis made by Denmark of the correlation between bird migration and the weather.
By relating strikes (and damage level) to bird migration and suitable bird migration weather it was proven that the remarkable increase in damage occasioned by birdstrikes (in contrast to foreign countries) runs parallel to the increasing disbelief in and its consequent disinterest for preventive measures. At the same time in the 1966 - 1970 period it appeared to be cost-effective after all. Graphs will be shown in illustration of all this.

3. The Netherlands situation illustrates how matters can water down despite an initial enthousiastic start. It emphasizes the need for a liberal approach with investments that cannot always be immediately judged by their effect. It seems important to make the following recommendations:

a. A regular official should be appointed, which may guarantee a relation of confidence;

b. A satisfactory co-operation of an ornithologist, a radar expert and maybe a meteorologist should be established. The nature of bird movements is too difficult a matter to be interpreted by a layman; old theories are to be revised on the basis of recent results of radarinvestigation into bird migration; the effect which the weather has on bird migration has not yet been sufficiently examined so as to come to prediction systems. On the other hand the possibilities to employ radar increase and the biologist grows more dependent on a radar expert;

c. Bird migration data should be exchanged and standardization should be achieved among the different countries. Prevention systems cannot be more discredited than by a change in bird migration intensities as soon as one crosses the border;

d. Information on birds and bird movements should be supplied within the organization as a primary condition to maintain faith in the cause.

4. Recent RNLAF analyses of birdstrikes have led to positive policy decision in that at the moment possibilities are examined to set up a research and a restriction system once again.
It is hoped that we can closely co-operate with the other BSCE members.

BIRD STRIKE COMMITTEE EUROPE

Bird Movement Working Group

European Bird Hazard Map (Denmark)

As a preliminary Danish contribution to the joint European bird hazard map the enclosed two maps have been drawn. In order to elucidate the difficulties in adopting the German-Belgian proposals (9th Dec. 1974) for conditions in Denmark, we have used other criteria.

A) By using the criteria proposed practically all of Denmark and the surrounding waters should be classified as "high risk areas". For pilots operating in Denmark such information would be of no practical value and even represents a step backward compared to the detailed information already published and in use in Denmark.

B) In Denmark the bird-density and bird-strike risk varies considerably from area to area, often over very short distances. This has been illustrated in the official Low Level Charts and maps published in the Air Information Publication (AIP), where "high risk zones" in the sense this term has hitherto been used in Denmark, cover approximately 5% of the area and hold more than half of all waterbirds (gulls, waders, ducks, geese, swans etc).

Map I. Shows areas where water birds of the proposed categories B and C (more than 260 grams) regularly occur in densities exceeding 100 birds per sq.km. Thus the criterion used in this map is twice the German-Belgian proposals, and species belonging to category A are not considered at all.

Map II. Shows areas where densities of waterbirds regularly exceed 500 birds per sq.km (only categories B and C), i.e. densities ten times as large as proposed . This map is very similar to the national bird hazard maps hitherto used.

This preliminary presentation suggests that the criteria used in a joint European bird-hazard map are discussed at the BSCE meeting in Stockholm, June 1975.

Anders Holm Joensen

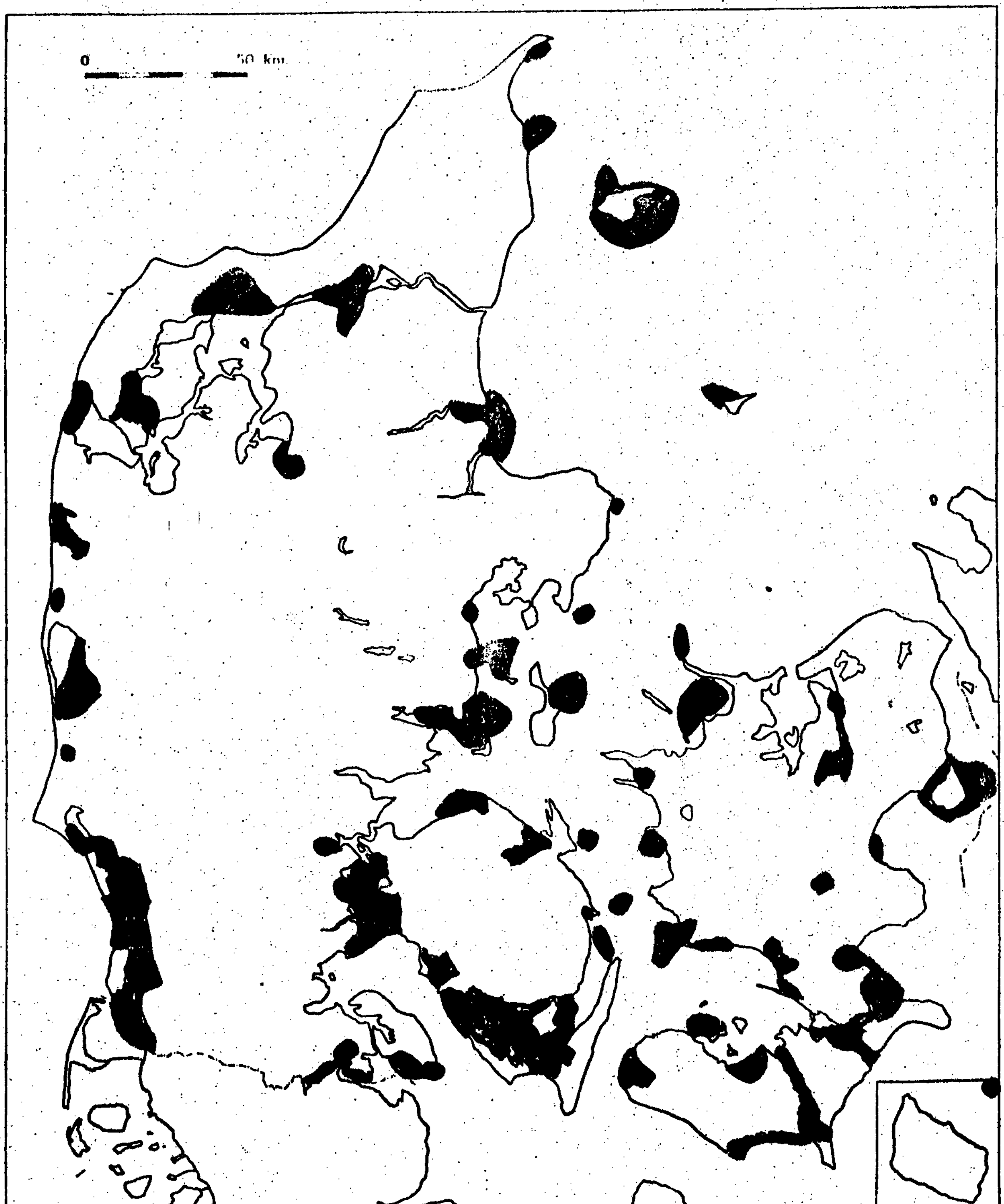
Anders Holm Joensen
Bird Strike Committee Denmark
Game Biology Station, Kalø
8410 Rønde, Denmark

20. May 1975

AD F616207

Indicating areas where the density of birds (category B and C, i.e. species of more than 260 g) exceeds 100 per sq. km during most of the year.

Indicating areas where the density of birds (categories B and C, i.e. species of more than 260 g) exceeds 500 per sq. km during most of the year.



BIRD STRIKE PROBLEMS AT BEN-GURION AIRPORT, LOD - ISRAEL.

by Sh. Suaretz, Israel.

General.

In December 1973 an El-Al plane full of passengers met during the take-off with a flock of birds - probably gulls. The pilot succeeded to brake, but as a result one of the motors was damaged and one of the back tyres burst. Fortunately nobody was hurt, but this incident served as a warning. The airport management looked for ways to avoid possible accidents, and among others, approached the Nature Reserves Authority, and thus I started to deal with the problem in January 1974.

Meanwhile the runways in the airport were being checked frequently, and if there were birds, a car was driven along the runway before or after take-off or landing of planes, in order to get rid of them. Obviously this method was not very effective.

When the matter was turned over to us, we immediately installed a number of gas cannons and also equipped the control people with shot-guns so that, if necessary, they could be put into action under controlled conditions. At the same time we started to investigate the special problems of the site, and we also collected know-how from every possible source in order to profit from the experience in other countries.

From the beginning we learned that we had to remove the principal sources of food for the birds, and we immediately initiated action to have the garbage dumps transferred from the neighbourhood of the airport.

At the end of 1974 I submitted to the airport management a report on the dangers of certain birds and proposal for short term measures as well as long term solutions. The present summary is mainly based on this report.

The site and its environs.

Ben-Gurion airport is situated in a densely populated area. Around the airport there are citrus groves and cultivated fields, and even between the runways big areas have been leased to farmers who grow there various crops, mainly industrial crops.

To the north west at a distance of about 5 kms there is the biggest garbage dump in the country to which many tons of garbage are delivered daily from Tel-Aviv and the neighbouring townships. Another smaller local garbage dump adjoins the airport on the north eastern side. These dumps are rich sources of food and attract many birds and are, therefore, the main cause of trouble.

The birds and their dangers.

1. The Black-headed Gull - Larus ridibundus. This species is found in great numbers, but only during the winter. They usually arrive in October, and within a short time thousands of gulls appear on the beaches, in the fields, on garbage dumps, at the fish ponds etc. Thousands come each morning to the garbage dumps near the airport from their dormitories on the beach. After stilling their hunger they rest in ploughed fields or in puddles formed by the winter rains and sometimes on one of the runways of the airport. They begin to leave us in March, and in April there are hardly any left.

2. The Rock Partridge - Alectoris graeca. This species is resident and is increasing in numbers and spreading to additional areas such as the coastal plain. This may be caused by the reduction in numbers of their natural enemies such as the jackal and the fox, but no doubt agricultural development which provides ample food had also a considerable influence. Therefore, the area of the airport which is rich in field crops attracts increasing numbers of partridges which are accustomed to hide in the citrus groves which adjoin the site, or on the airport itself in places with thick vegetation. In the course of their roaming through the area they frequently cross the runways either running or in low flight.

3. Other bird species which are a potential danger, even if to a lesser degree are the Lapwing - Vanellus vanellus, which appears in small numbers in the fields. The Starling - Sturnus vulgaris, which in some years appear in great numbers and then they can be found nearly everywhere in the area. The Cattle egret - Ardeola ibis is resident in the district and is sometimes found in the fields and at the garbage dumps but is hardly ever seen within the boundaries of the airport. Doves and Pigeons - Streptopelia and Columba are present in considerable numbers but usually outside the ~~t~~ site.

From this data it was clear that we had mainly to act against the gulls and the partridges while observing their behaviour in the neighbourhood. There is also reasonable hope that we shall be able to reduce, if not entirely to eradicate the risk by the other above mentioned species.

Measures to solve the problem.

The proposals made in the beginning to the airport magament were:-

1. Removal of the many sources of food, or at least reducing them to a minimum.
2. To stop the growing of field crops within the boundaries of the airport, or at least to determine which crops may be~~g~~ grown which do not attract birds.
3. To encourage hunters to shoot partridges under controlled conditions on the site of the airport, even in the breeding season when shooting is not permitted in this country.
5. To drain puddles of water remaining within the boundaries of the airport and around it.
5. To use various means of scaring and driving the birds away such as gas cannons, stuffed birds or carcasses of these birds, distress cries etc.

The present position (1975).

Since the first incident in December 1973 there were a small number of bird strikes, mainly with El-Al planes but also some foreign airlines, though fortunately no serious cases. Altogether, we know of 5 bird strikes only, and in two of the cases one of the motors was affected. In one instance feathers of a rock partridge which got into the motor during the take-off was found, but no damage was caused. In addition there were a few instances when the take-off of a plane had to be delayed until birds which were on the runway or near it had been removed.

Obviously, these cases obliged us to look for further effective measures. Meanwhile the airport management has been successful in negotiating the removal of the garbage dumps from their present location to a reasonable distance, probably in the course of this year, and I believe that this will be a great step forward.

The airport management has agreed to the necessity of appointing one man for the operation of the measures against bird strike, who will also be responsible for trying out new methods.

In the meantime contact has been established with various organisations in Canada, U.S.A. and European countries, mainly Holland, from whom we got very valuable advice and instructive material.

On the basis of this advice, we are now going to/use as scaring methods dummies, bird scare pistols, distress call tapes, and all this in addition to the gas cannons which, in my opinion, are most effective at least against gulls, if they are operated only for short periods and in the right locations.

Last winter we also made a trial with a chemical repellant. The material which is manufactured in the U.K. under the trade name Curb is an Aluminium-Ammonium- Sulfate which causes irritation and drives the birds away. It has been tried out for agricultural crops, in some cases successfully, especially if alternative sources of food for the birds were available. We sprayed the small garbage dump and also the length of the runway which is used as a resting place by the gulls and is crossed by the partridges. Unfortunately, our first trial was not successful due to unfavourable weather conditions, but I intend to repeat the trial in the next season.

Furthermore, a proposal has been made to create artificial pools at a considerable distance from the site thus drawing at least some of the birds away from the area.

__Summary.__

Our operations concentrated first of all on getting rid of the garbage dumps in the neighbourhood and on the utilisation of the areas between the runways in a way which does not attract birds. We took measures to frighten and scare gulls and partridges and to restrict the partridge population by shooting.

I want to take this opportunity to thank all the people and organisations who have assisted and advised us, and the BSCE who invited me to take part in this session. My special thanks are due to Dr. Stortenbeker and his colleagues in Holland from whom we received invaluable help and instruction.

Shalom Suaretz
Chief Ornithologist,
Nature Reserves Authority.

221

SPRING MIGRATION OF CRANES OVER SOUTHERN SCANDINAVIA

Thomas Alerstam

Department of Animal Ecology, Zoological Institute, University of Lund

Although bird migration since long has been a topic of intensive research, there is still a wealth of fundamental facts to be unravelled. This becames particularly evident when ornithologists are asked by aviation authorities to supply information that may be useful for preventing collisions between birds and aircraft. The existing data on numbers of birds, geographical and diel patterns of migration, flight altitudes, migratory activity in relation to weather and so on, are quite unsufficient. Thus, ornithologists must start collecting such data, giving priority to bird species, that represent the greatest hazards to airplanes, and which could be successfully studied by available methods, i.e. in most cases by field and radar observations.

In Sweden, after cooperation between the Air Force, the Board of Civil Aviation, the Department of Animal Ecology, University of Lund, and Falsterbo Bird Station had been established, a joint project to study bird migration in southern Sweden was started in 1971. An effort has been made to map different main types of bird migration, such as winter movements of waterfowl, diurnal migration of passerines, notably finches, and nocturnal migration of passerines, particularly trushes. The focus, however, has so far been centered on the migration of three species, i.e. the Eider S o m a t e r i a m o l l i s s i m a, the Wood Pigeon C o l u m b a p a l u m b u s and the Crane G r u s g r u s. As an ornithologist participating in the project it is my hope that the information gathered will provide answers to some of the questions raised by air traffic authorities and that it will contribute to the development of efficient bird warning systems.

To give an example of recent bird migration studies in Sweden I will briefly review some results concerning the spring migration of the Crane over southern Scandinavia. In this instance, radar monitoring and field observations provided complementary data yielding an exceptionally full picture of the migratory process. Details not only of this study but of all investigations conducted by the joint research project will be found in the publications in the reference list (included as an appendix).

1) Geographical pattern. The Cranes rest in large numbers at several sites on the southern coast of the Baltic, especially on the island of Rügen. They depart over the Baltic towards almost due north and cross central Skåne. Many of the birds later gather to rest at Lake Hornborgasjön, 400 km north of Rügen. About 75 % of the Scandinavian Cranes depart from Rügen or from the coast immediately west of this island; a small part arrive via Denmark (10 %) and a still smaller fraction from Poland (1 %).

2) Diel pattern. Departures towards north from Rügen take place between 0530 and 1400 hrs. A smaller peak of departures often takes place from 0600-0830 hrs, while most birds depart between 1030 and 1300 hrs. The Cranes generally reach the central part of Skåne after about two hours' flight and Hornborgasjön after a travelling time of less than eight hours.

3) Numbers of Cranes. By way of counting radar echoes from Crane flocks and multiplying with the mean flock size, based on field records, it was concluded that at least 25 000 birds pass through southern Scandinavia in spring.

4) Weather conditions during migration. This problem has not yet been analysed in detail, but intensive Crane migration consistently coincides with following winds.

5) Cruising technique. Crane flocks behave in a markedly different way over sea and land, respectively. Over the Baltic Sea radar echoes of Crane flocks move with a constant rate of progress indicating continuous active flight. Over land the same echoes frequently halt for a brief period, move for a short distance to make another halt, and so on. Such behaviour clearly reflects the technique of flight used by birds soaring in thermal air. Soaring of Crane flocks lasts on the average 6.3 minutes, and the mean distance travelled between soaring interludes is 13.3 km.

6) Speed. The true air speed for travelling over the sea is 67 km h^{-1} (the mean ground speed is higher due to the tailwinds, viz. 77 km h^{-1}). Over land, the height gain obtained from soaring in thermals has to be paid for in slower cruising speed; true air speed is only 44 km^{-1} (mean ground speed 50 km h^{-1}). True air speed during the flights between thermals is about 70 km h^{-1}

7) Flight altitudes. Flight altitudes of Crane flocks, as measured by radar over southernmost Skåne, varies between 200 and 700 m. Very few flocks have been recorded above the cloud base, and flight altitudes seem to be positively correlated to the altitude of the cloud ceiling.

8) Wind drift. The Cranes compensate completely for wind drift over land, but only incomplete compensation takes place over the sea. Hence, arrivals to the south coast of Skåne occur more to the west under easterly winds and vice versa. The angle between the Cranes' heading and track directions over the sea is composed of 68 % compensation and 32 % drift.

APPENDIX

List of references - Swedish bird migration project

Department of Animal Ecology, University of Lund
Falsterbo Bird Station
Swedish Air Force
Swedish Board of Civil Aviation

1. Alerstam, T. & Ulfstrand, S. 1972. Fågelsträcket över Skåne studerat medelst radar och av fältobservatörer. - Medd. Skånes Orn. För. 11: 1-6.

2. Alerstam, T. & Ulfstrand, S. 1972. Radar and field observations of diurnal bird migration in South Sweden, autumn 1971. - Ornis Scand. 3: 99-139.

3. Alerstam, T. 1972. Nocturnal bird migration in Skåne, Sweden, as recorded by radar in autumn 1971. - Ornis Scand. 3: 141-151.

4. Alerstam, T. & Ulfstrand, S. 1973. Fågelsträcket över Skåne ett septemberdygn 1972 - Medd. Skånes Orn. För. 12: 1-11.

5. Alerstam, T. & Bauer, C.-A. 1973. A radar study of the spring migration of the Crane (Grus grus) over the southern Baltic area. - Vogelwarte 27: 1-16.

6. Alerstam, T., Lindgren, A., Nilsson, S.G. & Ulfstrand, S. 1973. Nocturnal passerine migration and cold front passages in autumn. - Ornis Scand. 4: 103-111.

7. Alerstam, T., Bauer, C.-A. & Roos, G. 1974. Fält- och radarstudier av östersjöejdrarnas Somateria mollissima vårsträck. (Summary: Field- and radar studies of the spring migration of the Baltic eider Somateria mollissima). - Vår Fågelvärld 33: 15-27.

8. Alerstam, T. & Ulfstrand, S. 1974. A radar study of winter bird movements in southern Scandinavia. - Ornis Scand. 5: 13-23.

9. Alerstam, T., Bauer, C.-A. & Roos, G. 1974. Spring migration of Eiders Somateria mollissima in southern Scandinavia. - Ibis 116: 194-210

10. Ulfstrand, S., Roos, G., Alerstam, T. & Österdahl, L. 1974. Visible bird migration at Falsterbo, Sweden. Vår Fågelvärld, Suppl. 8: I-XLIV, 1-245.

11. Alerstam, T. & Ulfstrand, S. 1974. A radar study of the autumn migration of Wood Pigeons Columba palumbus in southern Scandinavia. - Ibis 116: 522-542.

12. Roos, G. 1974. Ett försök med kedjeobservationer på Falsterbonäset under höststräcket. (Summary: Simultaneous observations of visible autumn migration at different sites near Falsterbo - a pilot study) - Anser 13: 137-148.

13. Karlsson, J. & Alerstam, T. 1974. Flyghöjden hos flyttande tranor Grus grus över sydligaste Skåne - bestämning med hjälp av radar. (Summary: Radar measurements of flight altitudes of migrating Cranes, Grus grus, over southernmost Skåne, Sweden.) - Vår Fågelvärld 33: 265-269.

14. Roos, G. 1974. Sträckräkningar vid Falsterbo hösten 1974. (Studies on visible migration at Falsterbo in autumn 1973) - Vår Fågelvärld 33: 270-285.

15. Alerstam, T., Karlsson, J. & Ulfstrand, S. 1975. Översikt över flyttfågelkoncentrationer under hösten i Sydsverige. - Berlings, Lund (29 pp).

16. Alerstam, T. 1975. Redwing (Thurdus iliacus) migration towards southeast over southern Sweden. - Vogelwarte 28.

17. Alerstam, T. 1975. Crane Grus grus migration over sea and land. - Ibis 117.

18. Alerstam, T. & Ulfstrand, S. 1975. Diurnal migration of passerine birds over South Sweden in relation to wind direction and topography. - Ornis Scand. 6.

227

BIRD STRIKES IN SWEDEN 1967 - 1974

Johnny Karlsson

Data on bird strikes with Swedish military and civil aircraft has been systematically collected for many years, and it is thus possible to make a retrospective analysis of some fundamental aspects. This report presents military bird strikes for the years 1967-1974 and collisions with civil aircraft registered in Sweden for the period 1968-1974.

NUMBER OF BIRD STRIKES

Number of bird strikes, strike frequency and damage frequency are presented in Tables 1 and 2.

A total of 418 collisions with civil aircraft have been reported during the years 1968-1974. About one-fourth of the strikes have ocurred abroad. The rate of strikes per 10 000 movements has varied from 0.40 to 0.75, with a slight increase in later years. Compared with the figures given below for the Swedish airforce and the strike rates presented from many other countries, the strike frequency in civil aviation in Sweden appears to be fairly low.

The Swedish airforce has reported about 1400 bird strikes for the eight years 1967-1974. About 16 % of the strikes caused damage to the aircraft, six aircrafts were lost and four humans died in four of these accidents. The strike frequency oscillated from 4.1 in 1967 to 6.2 in 1974.

The great difference in strike frequency between civil and military aviation is mainly due to the fundamental differences in flying; the military aircrafts

mainly operating at low altitudes. The relationship between flight altitude and strike frequency is clearly shown in Table 3. Ground attack an reconnaissance, operating at very low altitudes, has about five time as high strike rate as the other units, which operate at higher altitudes. Another characteristic of the military flights, compared with civil aviation, is that about 60 % of the strikes appear outside the start/ landing stage on the military side but only 29 % for the civil aircraft, see Table 5.

ECONOMIC ASPECTS OF THE BIRD STRIKES

In Table 4, the known (and in some cases estimated) costs of repair are presented for the different years. In 1974, when the costs were checked rather closely, these were about 3/4 mill Skr. for civil as well as military aviation. Many of the consequences of a bird strike, however, are hard to measure in money. Totally lost military aircrafts for exampel do not give any "costs" at all.

The total cost of repairs due to birds for the Scandinavian Airlines System (SAS) are also presented. As well as the true bird strikes, there are many engine damages caused by ingestion of foreign objects (FOD), and it seems plausible that a part of this is caused by birds.

ALTITUDE DISTRIBUTION OF BIRD STRIKES

The distribution of the bird strikes at different altitudes is presented in Figure 1 (civil) and Figure 2 (military). As usual, most of the strikes occur at very low altitudes; about two thirds of the strikes in Sweden take place below 100 m in both civil and military activities. Very few accidents with bird have been recorded at altitudes of 1000 m or more on the military side, but in civil flight about 10 % of the strikes have been recorded at this altitude. Light aircraft (5 700 kg),

1787

which mainly operate at fairly low altitudes even on "en route" have rather many strikes at the altitude 200 to 500 m, compared with large jet machines.

SEASONAL DISTRIBUTION OF THE BIRD STRIKES

The drastic seasonal changes in the number of birds occuring in Sweden is clearly reflected in the monthly distribution of bird strikes, (Figures 3,4). There are very few strukes in the winter months (December, January and February), when most of the birds have left the country. The worst period is from June to October with peaks in July and August. The reasons to this distribution of the collisions are: flocking of the birds after the breeding period, many inexperienced birds and (mainly) the autumn migration.

GEOGRAPHICAL DISTRIBUTION

The birdstrike frequency at the different airfields in Swedn is shown in Figures 5 (civil) and 6 (military). The rates given in the figures refers only to start/landing stages, and is given per 10 000 movements.

Four trends can be separated from the figures: 1) decreasing rate from south to north, 2) decreasing from coastal to inland areas, 3) higher strike frequency in agriculture compared with woodland areas at the same latitudes and 4) low relative frequency at airports with intense traffic.

BIRDS INVOLVED IN STRIKES

Exact information on the birds involved in strikes is rather scarce. Remains of birds from strikes with military aircrafts has, however, been collected and analysed during the three years 1972-1974 (Table 6) On the civilian side, birds found dead after incidents

with starting or landing planes at the new airport Malmö/Sturup in southernmost Sweden, are listed in Table 7. In total, 37 species of birds has been registered in this two investigations. Gulls were involved in 37 % of the strikes; the Common Gull being the commonest species. Number of strikes involving various bird groups was as follows: ducks 2, birds of prey 12, waders 5, gulls 42, swifts 7, swallows 4 and others 43.

(The data presented in this paper about military bird strikes has been worked up by Th. Alerstsm, Swedish Airforce.)

Johnny Karlsson
Board of Civil Aviation, Sweden

Present adress: Ecology Building
Dept. of Animal Ecology
University of Lund
Helgonavägen 5
S-223 62 LUND

Sweden

A 29

Tab 1

Bird strikes with Swedish aircrafts reported to the Board of Civil Aviation 1968-1974.

Year	Strikes in Sweden	Strikes outside Sweden	Rate per 10 000 movements on civil airports in Sweden	Strikes causing damage	Estimated cost of repairs Skr
1968	42	6	0.51	19	
1969	37	12	0.51	9	350 000
1970	38	12	0.42	14	560 000
1971	42	13	0.40	21	580 000
1972	46	17	0.53	10	50 000
1973	57	25	0.75	12	130 000
1974	49	22	0.64	16	750 000

230

Tab 2

Bird strikes in the Swedish airforce 1967-74.

Year	Number of strikes	Strikes per 10 000 move-ments	Number of strikes causing damage	Strikes causing damage per 10 000 move-ments	Number of aircrafts lost	Humans killed	Cost of repairs Skr
1967	143	4.1	12	0.4	1	-	100 000
1968	155	4.7	19	0.6	-	-	270 000
1969	161	4.9	29	0.9	1	-	220 000
1970	184	5.7	29	0.9	1	2	430 000
1971	186	5.4	26	0.8	-	-	90 000
1972	179	5.5	33	1.0	-	-	180 000
1973	186	5.8	28	0.9	2	1	480 000
1974	183	6.2	40	1.4	1	1	750 000

Tab 3

Bird strikes in other stages than start/landing at the military airfields in Sweden.

Airfields		Flight action	Strikes per 10 000 movements
F 1	Västerås	Fighter	5.8
F 3	Linköping	"	3.8
F 4	Östersund	"	3.0
F 5	Ljungbyhed	Training	3.1
F 6	Karlsborg	Ground attack	19.0
F 7	Såtenäs	"	15.7
F 8	Barkarby	Transport	2.3
F 10	Ängelholm	Fighter	3.9
F 11	Nyköping	Reconnaissance	29.0
F 12	Kalmar	Fighter	2.8
F 13	Norrköping	"	3.3
F 15	Söderhamn	Ground attack	14.5
F 16	Uppsala	Fighter	8.5
F 17	Ronneby	Ground attack	13.7
F 18	Tullinge	Fighter	5.2
F 20	Uppsala	Training	5.0
F 21	Luleå	Reconnaissance-Fighter	5.8

232

Table 4

Cost of repaors due to bird strikes (Skr).

The costs for the Swedish Airforce does not include lost aircraft, and and the figures for the civil aviation are partly estimated.

The total costs for the entire Scandinavian Airlines System (SAS) are also given. FOD refers to "Foreign Object Damage", and it can be supposed that these accidents are partly caused by birds.

Year	Swedish airforce	Civilian aircrafts	SAS (Scandinavian Airlines System) bird strikes	SAS (Scandinavian Airlines System) FOD
1967	100 000	-	-	-
1968	270 000	?	469 000	718 000
1969	220 000	350 000	655 000	517 000
1970	430 000	560 000	555 000	430 000
1971	90 000	580 000	370 000	709 000
1972	180 000	50 000	856 000	679 000
1973	480 000	130 000	1 321 000	1 161 000
1974	750 000	750 000	475 000	992 000

Tab 5

Bird strikes at different flight stages. Refers to strikes sustained by the airforce from 1967 to 1974, and sustained by civil aviation from 1968 to 1974.

	Strikes at start	Strikes at landing	Strikes at other stages
Swedish airforce	25 %	16 %	59 %
Civil aircrafts, total	27 %	44 %	29 %
Civil aircrafts, < 5700 kg	22 %	36 %	42 %
Civil aircrafts, > 5700 kg	29 %	47 %	24 %

Tab 6

Number of strikes with different birds in the Swedish Airforce in 1972-1974. Strikes that caused damage to aircraft are given in brackets. The birds has been identified from remains collected from the aircrafts.

Red-breasted Merganser	Mergus serrator	1	(1)
Common Buzzard	Buteo buteo	4	(2)
Goshawk	Accipiter gentilis	1	(1)
Kestrel	Falco tinnunculus	2	(1)
Oystercatcher	Haematopus ostralegus	1	(-)
Lapwing	Vanellus vanellus	2	(1)
Golden Plover	Pluvialis apricaria	1	(-)
Black-backed Gull	Larus marinus	1	(1)
Herring Gull	Larus argentatus	4	(3)
Common Gull	Larus canus	10	(5)
Black-headed Gull	Larus ridibundus	9	(3)
Gull (Indet.)	Larus spp.	10	(7)
Wood Pigeon	Columba palumbus	1	(1)
Tengmalm´s Owl	Aegolius funereus	1	(1)
Swift	Apus apus	7	(4)
Skylark	Alauda arvensis	4	(-)
Swallow	Hirundo rustica	1	(-)
House Martin	Delichon urbica	1	(-)
Hooded Crow	Corvus corone	1	(1)
Magpie	Pica pica	2	(1)
Great Tit	Parus major	1	(-)
Blue Tit	Parus caeruleus	1	(-)
Fieldfare	Turdus pilaris	4	(1)
Song Thrush	Turdus philomelos	2	(1)
White Wagtail	Motacilla alba	1	(-)
Great Grey Shrike	Lanius excubitor	1	(-)
Starling	Sturnus vulgaris	4	(2)
Greenfinch	Chloris chloris	1	(-)
Linnet	Carduelis cannabina	2	(-)
Bullfinch	Pyrrhula pyrrhula	1	(-)
Chaffinch	Fringilla coelebs	2	(-)
Brambling	Fringilla montifringilla	1	(-)
Yellowhammer	Emberiza citrinella	2	(-)
Snow Bunting	Plectrophenax nivalis	3	(1)
House Sparrow	Passer domesticus	1	(-)
	Total	91	(38)

Tab 7

Number of strikes with different birds and mammals at Malmö/Sturup airport from Dec 1972 to April 1975. Numbers refer to carcases collected on the runways.

Birds:	Mallard	Anas platyrhynchos	1
	Buzzard	Buteo buteo	1
	Hobby	Falco subbuteo	1
	Kestrel	Falco tinnunculus	3
	Lapwing	Vanellus vanellus	1
	Black headed Gull	Larus ridibundus	3
	Common Gull	Larus canus	5
	Sky Lark	Alauda arvensis	3
	Swallow	Hirundo rustica	2
	Blackbird	Turdus merula	1
	White Wagtail	Motacilla alba	1
	Starling	Sturnus vulgaris	1
	Hooded Crow	Corvus corone	1
			24
Mammals:	Bat		1
	Fox		2
	Badger		1
	Hare		8
			12

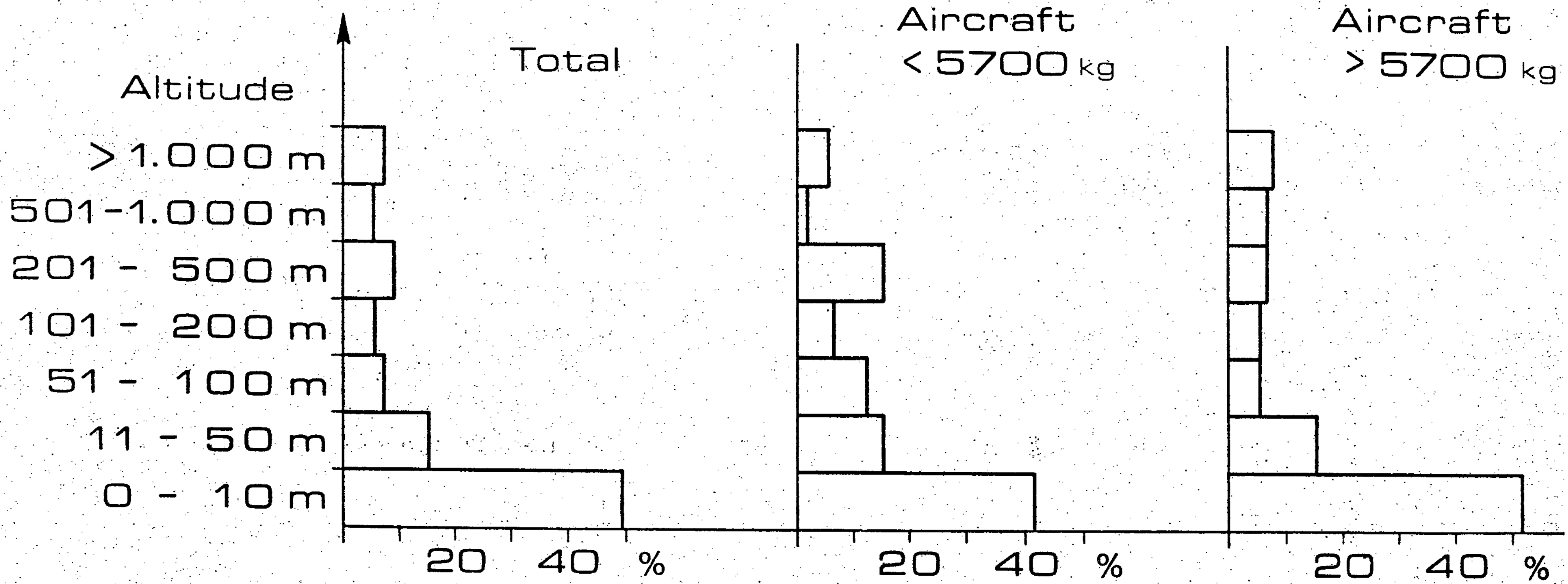
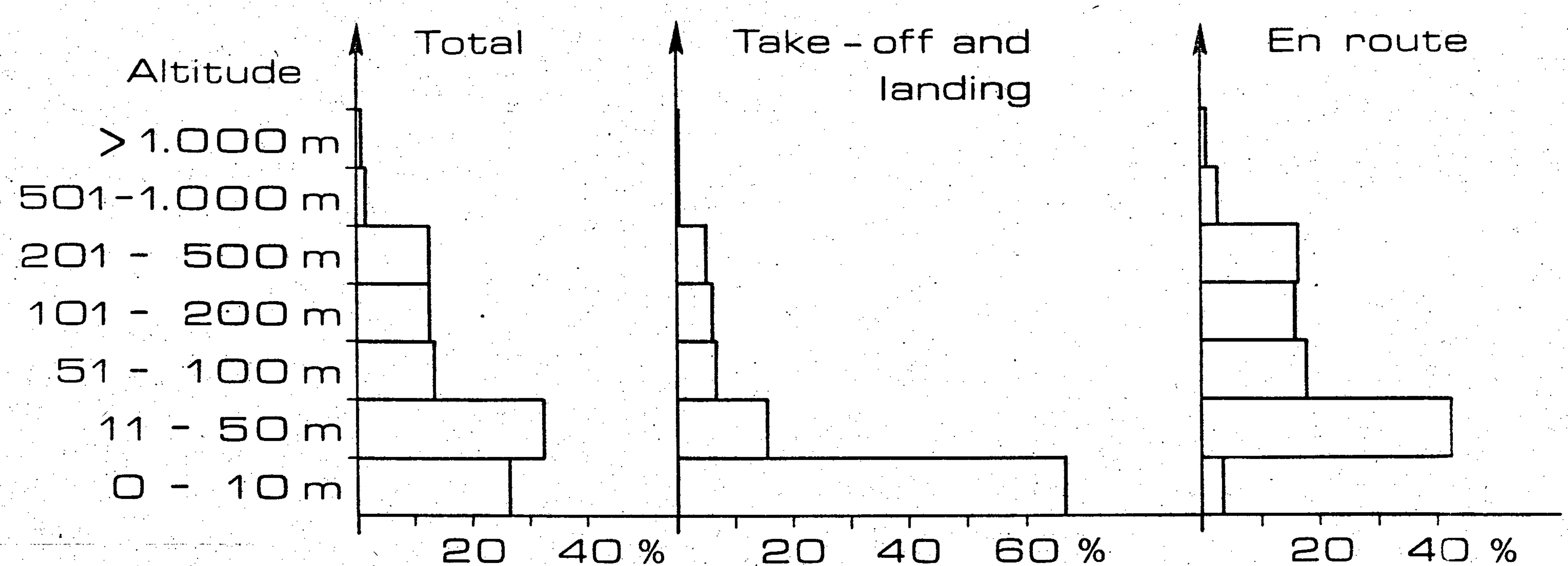


Fig 1

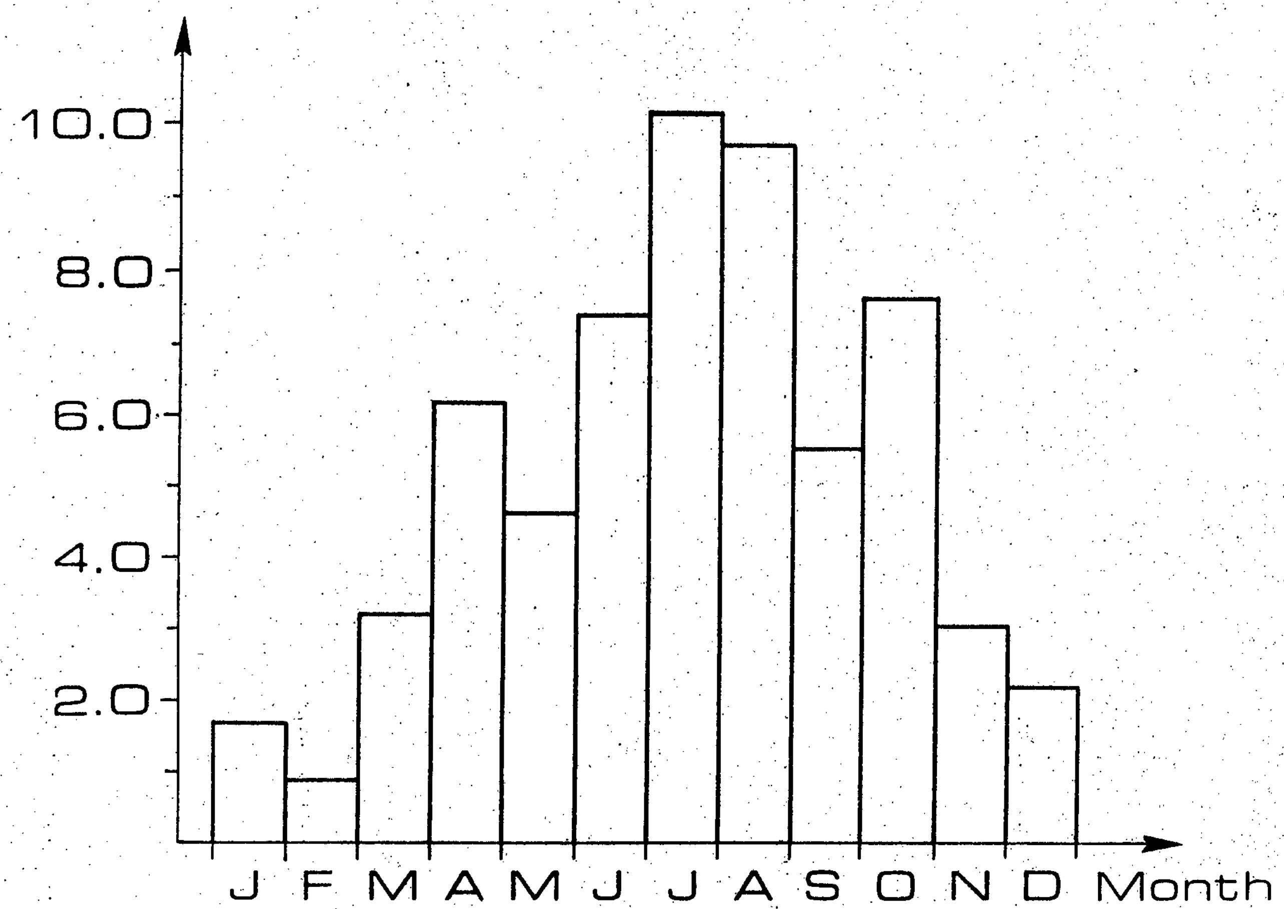
Altitude distribution of bird strikes in civil aviation, Sweden, 1968-1974. Based on about 300 strikes.



Altitude distribution of bird strikes in the Swedish Airforce, 1967-1974. Based on about 1000 strikes.

Fig 2

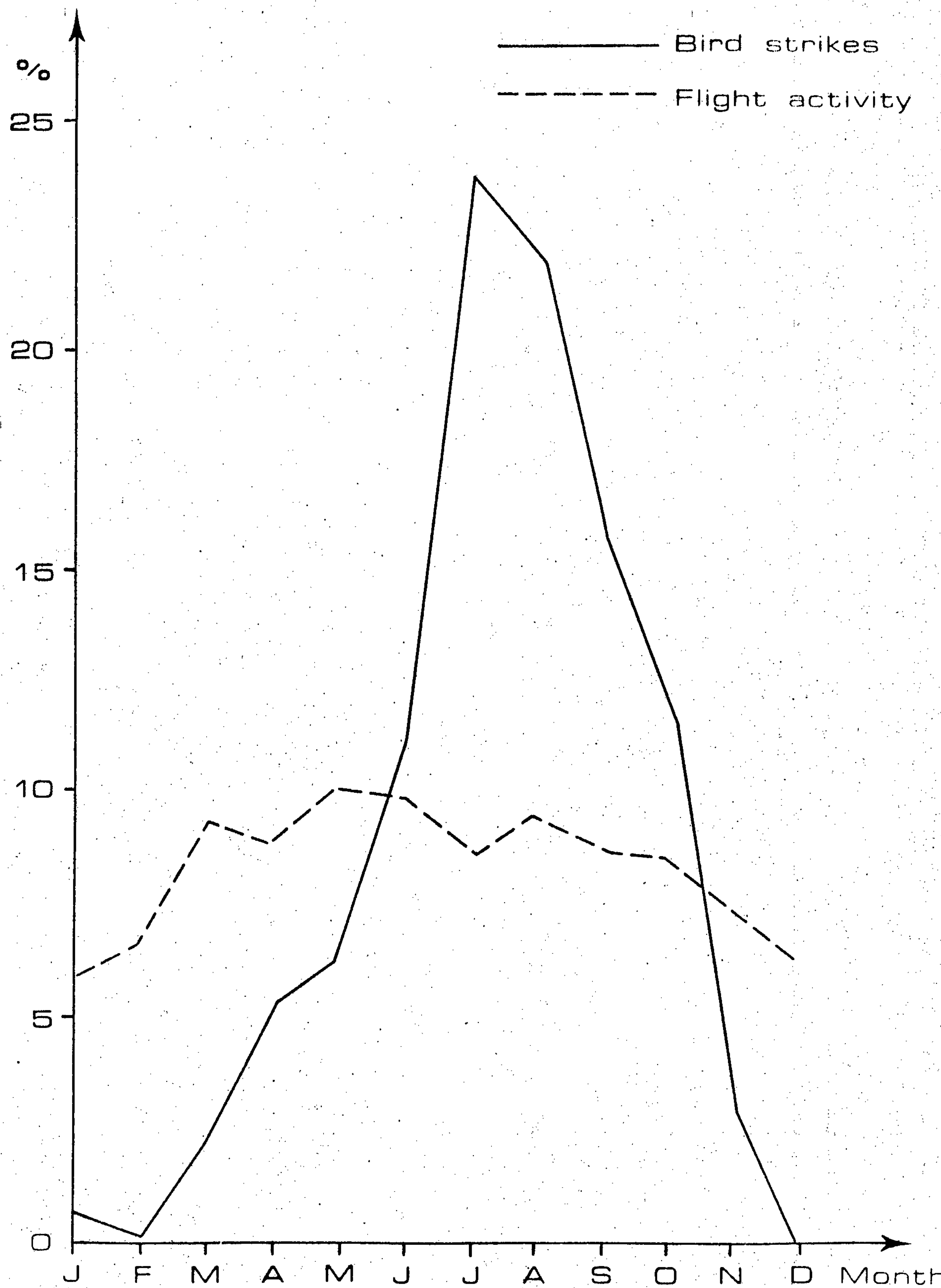
Fig 3



Monthly distribution of bird-strike frequency (per 10 000 movements) in the Swedish Airforce, 1967-1974. Based on about 1400 strikes.

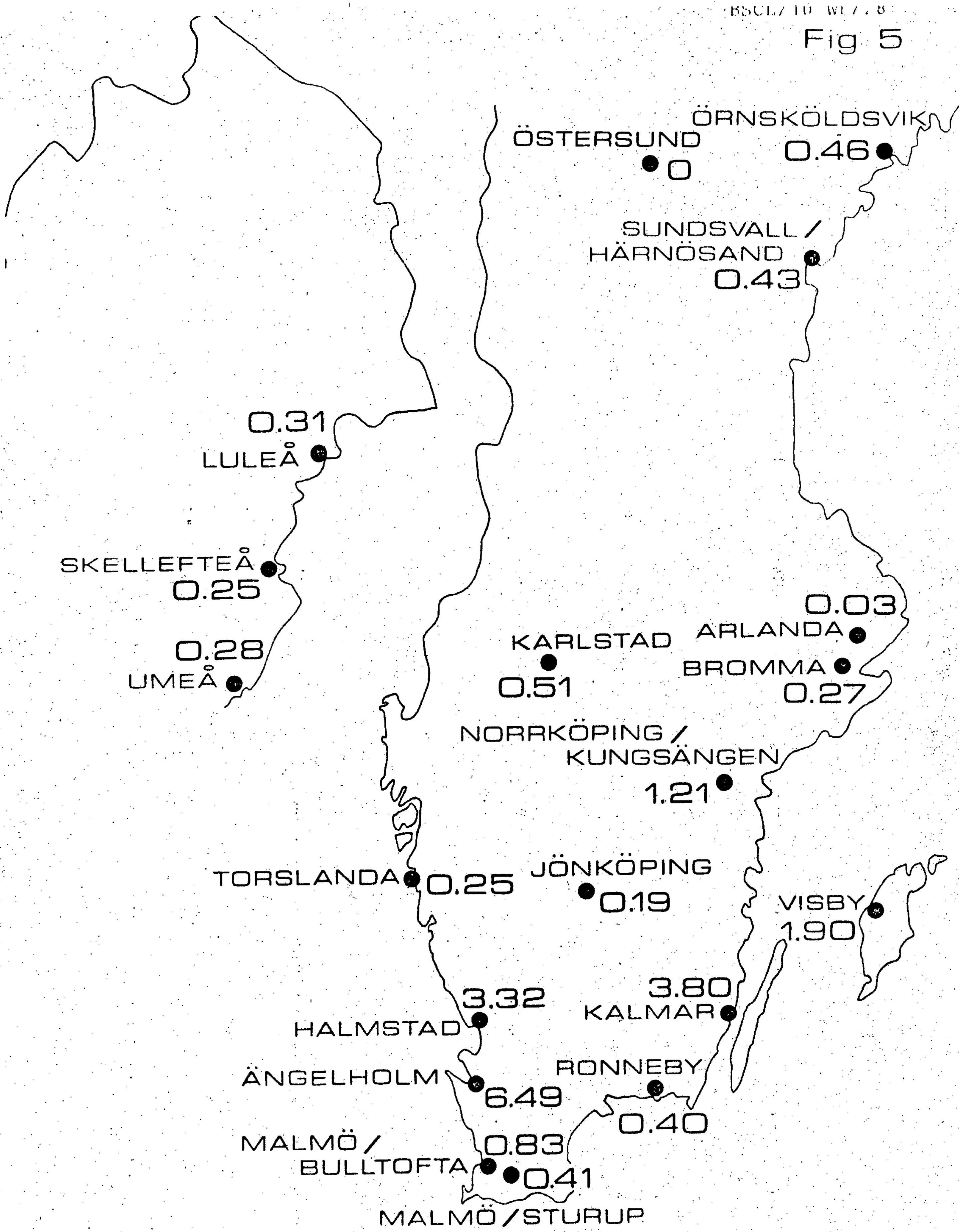
238

Fig 4



Bird strikes in relation to flight activity. The figure shows the situation in civil aviation in Swed[illegible]

Fig 5



240

Bird-strike frequency per 10 000 movements at the civil airports in Sweden, 1968-74.

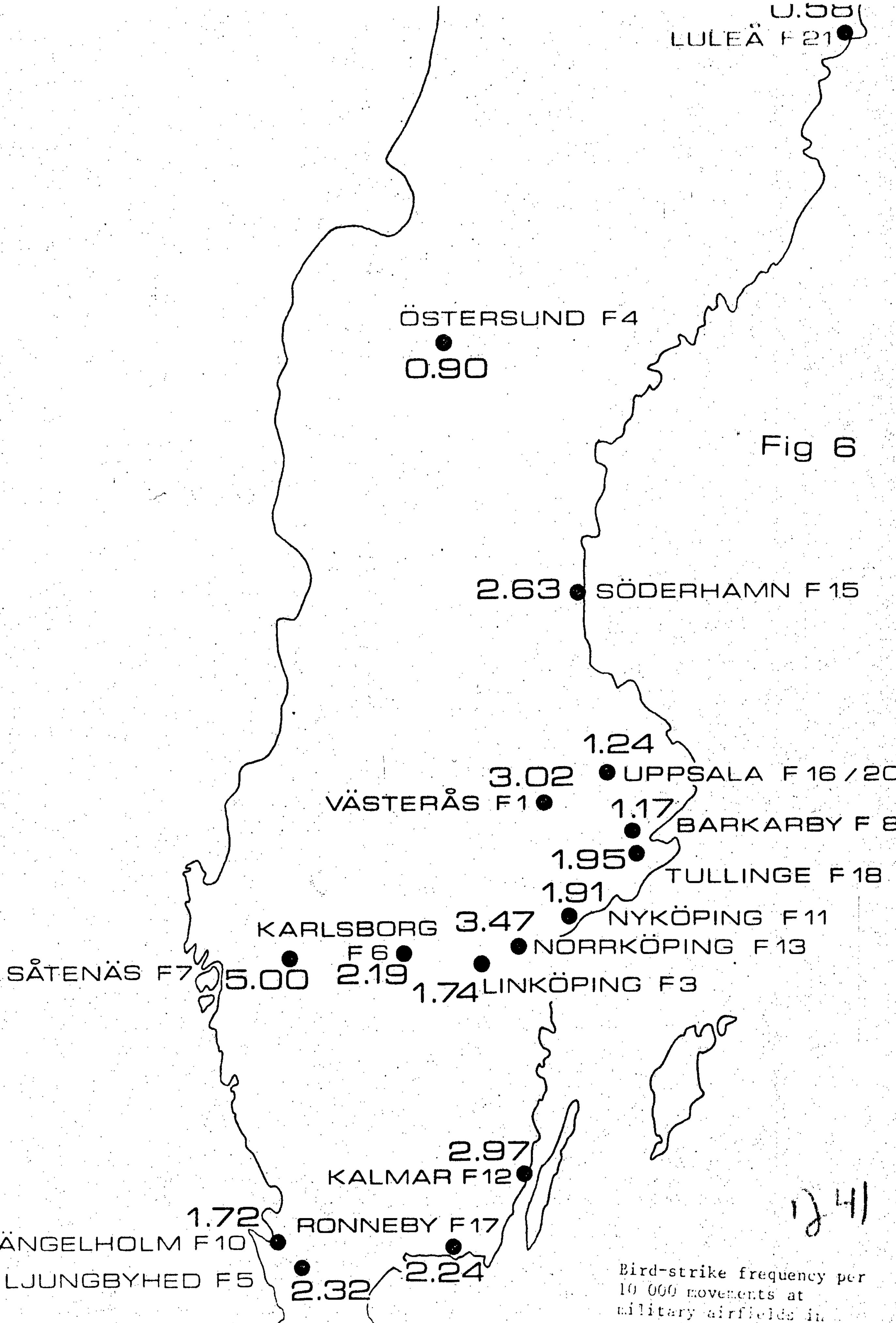


Fig 6

1241

Bird-strike frequency per 10 000 movements at military airfields in Sweden [illegible]

Paper to be presented at the 10th meeting Bird Strike Committee Europe
Stockholm June 1975

The Use of Waterfowl Count Data in Bird-strike work in Denmark

By Anders Holm Joensen, Bird-strike Committee Denmark
Game Biology Station, Kalø, 8410 Rønde, Denmark

During the seven year period 1968-1974 321 bird-strikes involving Danish military aircraft operating in Denmark were registered. In 153 (48%) of the cases the species of bird was determined. In 90 bird-strikes the aircraft was damaged, and in 38 (42%) of these cases the bird species was determined. See Table 1.

Table 1. The distribution on bird groups of 153 bird-strikes in which the species of bird was determined. Royal Danish Airforce 1968-1974. Information from Bird-strike Summary Report Forms, issued by Tactical Air Command.

Species/family/order		No. bird-strikes	%	No. bird-strikes with damage	%
Gulls	Laridae	61	40	22	58
Passerines	Passeriformes	46	30	6	16
Birds of prey	Falconiformes	15	10	5	13
Waders	Charadridae	13	8	2	5
Partridge	Perdix perdix	5	3	-	-
Pigeons/doves	Columbidae	5	3	-	-
Ducks	Anatinae	4	3	2	5
Longeared Owl	Asio otus	2	1	-	-
Swift	Apus apus	2	1	1	3

51% of all bird-strikes and 68% of the bird-strikes with damage to aircraft involved species which are more or less associated with water (gulls, waders, ducks), and gulls in particular account for a notable proportion. Also birds of prey are relatively hazardous. Small passerines are often involved in bird-strikes, but seldom cause damage. Larger passerines (Corvus monedula) have only once been registered in a bird-strike.

The high frequency of waterbirds in the statistics is a natural consequence of their relative importance in the bird-fauna of Denmark. The country has a very long coastline, several hundred small islands and huge areas of shallow salt water areas extending far out into the sea. The country is situated on one of the main migration routes for waterbirds in Europe and offers favourable conditions for resting waterbirds throughout the year.

In 1965 the Game Biology Station initiated a research programme of counting and mapping waterfowl populations with emphasis on ducks, geese and swans (Anatidae). The scope of the programme was in the beginning entirely biological, but from 1968 the Game Biology Station joined the national bird-strike work, and the scope of the waterfowl counts were widened to cover bird-strike aspects associated with all types of waterbirds: Anatidae, gulls, terns, waders etc.

AD F 616 211

The mapping of waterbird concentration areas has comprised both regular counts from the ground in selected inland and coastal wetlands, and aerial surveys over coastal and offshore waters. Ground counts were mainly conducted by amateur ornithologists, and in the period 1965-1973 more than five hundred participated and supplied nearly twenty thousand reports. Aerial surveys were made from single engined aircraft, partly hired by the Game Biology Station, partly assigned to the project by the Royal Danish Airforce and the Army Air Corps. In the period 1965-1973 950 hours were spent in the air. Ground counts and aerial surveys together resulted in the registration of fifty million Anatidae, twenty million gulls, and several million other waterbirds.

The results of the study concerning the size and distribution of Anatidae has been published by JOENSEN (1974 b), and the report gives background information for the future conservation and management of their populations in Denmark.

The bird-strike aspects have been described in maps used by all pilots in Denmark (Air Information Publication Maps and Official Low Level Charts), showing areas where waterbirds constitute a particular hazard to low flying aircraft. In these maps not only the numbers of birds but also the habits of the different species have been considered. Thus more attention has been paid to species regularly performing movements in the vicinity of their resting places (e.g. gulls, geese, dabbling ducks and waders) than to more stationary species (swans and some diving ducks). In AIP maps areas indicated as hazardous cover 2-5% of the total area of Denmark and surrounding waters, but hold between one-third and two-thirds of all waterbirds.

The studies during 1965-1973 have provided the following information on the size of waterbird populations in Denmark:

Ducks, geese, swans (Anatidae): For most species breeding populations are relatively small compared to other parts of Europe.- In summer min. 500.000 diving ducks, 40.000 mute swans (C.olor), many thousand dabbling ducks and geese moult in Denmark and the surrounding waters.- Peak numbers of visiting geese are found in autumn (up to 50.000) and spring.- Peak numbers of dabbling ducks occur in autumn, including up to 250.000 mallards (A.platyrhynchos) and 200.000 other dabbling ducks.- Most species of diving ducks have peak populations in late autumn and winter, when total numbers are up to 1.500.000. The most numerous are eiders (Somateria mollissima) 750.000, tufted duck (Aythya fuligula) 200.000, common scoter (Melanitta nigra) 200.000, goldeneye (Bucephala clangula) 75.000, scaup (Aythya marila) 75.000, and velvet scoter (Melanitta fusca) 40.000.- Peak numbers of swans are found in winter (up to 75.000).- For three species of swan and three species of diving duck Danish waters regularly hold more than half of the total European mid-winter population, and for several other species the country regularly holds more than one-quarter or one-third.

Gulls and terns (Laridae): The number of gulls breeding in Denmark has been roughly estimated to 200.000 - 250.000 pairs, including 50.000 - 70.000 pairs of herring gull (Larus argentatus), the most mobile and to aviation the most hazardous species of gull. The total population of gulls in summer is roughly estimated to two million, and in autumn peak numbers probably exceed three million, of which the herring gull comprises one-third or half.- The breeding population of terns probably does not exceed 20.000 pairs, and outside the breeding season numbers are generally much smaller.

9413

Waders (Charadriidae): The breeding population is probably of the order 10.000 - 20.000 pairs. In autumn and spring numbers regularly exceed 400.000 (excluding lapwing Vanellus vanellus), of which the large majority is concentrated in the Waddensea.

Other waterbirds: The numbers of coot (Fulica atra) in autumn and winter regularly exceeds 200.000. Numbers of grebes (Podicipedidae), divers (Gavidae), cormorants (Phalacrocoracidae) and auks (Alcidae) are generally small compared to the above mentioned groups.

References

Asbirk, S. & Joensen, A.H., 1974: Breeding populations of gulls in Denmark.- 9th Meeting Bird-Strike Committee Europe, Frankfurt (M) June 1974.

Joensen, A.H.,1974 a:The Species of Birds in Bird-Strikes with Military Aircraft in Denmark , 1968-1973.- CHF Flysik Orientering nr. 6 1974.

Joensen, A.H., 1974 b: Waterfowl Populations in Denmark 1965-1973. A Survey of the Non-breeding Populations of Ducks, Swans and Coot and their Shooting Utilization.- Danish Review of Game Biology vol. 9 no. 1, 206 pp.

AUTOMATIC WARNING OF HAZARDOUS BIRD CONDITIONS

F. R. Hunt

In the paper I presented at last year's meeting of Bird Strike Committee Europe, I described several methods of using radar for the detection of birds hazardous to aircraft. Four points were stressed at that time which are worth repeating.

1. The information produced by such equipments must be displayed to air traffic controllers in a form that is readily interpretable in order that the controllers' workloads are not significantly increased.

2. Personnel are not required to operate the equipment.

3. Increase in maintenance personnel should be minimal.

4. Initial and operating costs should be as low as possible consistent with the other requirements.

For the last two years in Canada, we have been working on two equipments to meet these requirements. The vertical automatic detection system was designed to provide warning of large scale nocturnal migrations which consist mainly of passerine birds. Although these birds are usually small in size, many of them are large enough in size to damage an aircraft's engine or fracture a wind shield if the aircraft is flying at high speed. Thus this type of migration is particularly dangerous to single-engined military aircraft flying at high speed and low altitude on low level training missions.

As was pointed out previously, if a high performance surveillance radar is available in the vicinity of the flying area and there are areas in its coverage free of permanent echoes, then the system developed by Denmark can be employed. If not, the following economical system can be used. It (Fig. 1) consists of a 6 ft. diameter antenna fixed in position so that it is pointing vertically. A cheap off-the-shelf marine radar transmitter-receiver is connected to it and to the Vertical Automatic Detection Equipment (VADE). Fig. 2 shows the block diagram of the latter unit. Commercially available integrated circuits have been used extensively

...... 2.

and these have provided a cheap but reliable unit. Six counter channels are provided which represent 1000 foot flight levels from 500 to 6500 feet above sea level. There are only two points to note in this diagram as standard circuits have been used. The first is the use of a simple video integrator in each height channel and this was found necessary to prevent interference from a nearby radar working in the same frequency band. The second circuit was added to solve the problem of a bird remaining in the antenna's beam for several seconds. As the bird beats its wings, its echo fluctuated and this often gave rise to multiple counts by that bird. To prevent these multiple counts, the multiple reply gates were added. These provide a dead-time to counting following the initial count of the bird. We have based the dead-time length on the maximum time it would take a bird to fly through the beam in any altitude band at a speed of 10 knots. As a matter of interest, typical wing beat patterns obtained with this radar are shown in Fig. 3. The time scale is approximately 1/4 second per large division. Revised tables of bird strike probability, which are of interest to the operational flying people and of the migration traffic rate of interest to ornithologists, have been worked out and include allowances for the dead-times. These tables are similar to those shown last year.

During the autumn migration of 1974, the equipment was operated approximately two nights a week by a technician and myself. A typical night of heavy migration occurred on the 3rd and 4th of October. The sensitivity of the equipment was set for detection of birds with radar cross-sections of 2 sq. cms. or greater. This is less than the 10 sq. cms. recommended for operational use but at that time, we were mainly interested in the performance of the equipment. Fig. 4 shows the counts obtained in each channel. Starting with zero counts shortly after sunset, the number of birds increases very rapidly. Fig. 5 shows the actual migration traffic rate in each height band as well as the total migration traffic rate. Fig. 6 shows the probability of a bird strike per nautical mile flown by an aircraft flying in one of these height bands. In developing this table, it should be noted that we had to assume a bird velocity and for our purposes 25 knots was used. Also we assumed a frontal area for the aircraft of 10 sq. ft. This corresponds to the frontal area of the engine and the wind shield of a single engined aircraft. This might be described as the catastrophic frontal area--i.e., a bird strike in this area could cause the loss of the aircraft and possibly the pilot. During the evening represented, the greatest probability of a bird strike was obtained in the 2000 ft. level at 0253 GMT when the probability was 2.38 per thousand miles flown. In the next figure (7), section 'a' depicts

...... 3.

0246

the increase in migration traffic rate with time. Part 'b' shows the bird distribution with height above ground level as the evening progressed. For instance at 0100 hours about 7% of the birds counted were flying between 1200 and 2200 feet, 33% between 2200 and 3200 feet and 40% between 3200 and 4200 feet.

The equipment performed satisfactorily last autumn. During the spring migration of 1975, the equipment has been operated nightly by an ornithologist. Only one major problem arose. This occurred when the antenna was blown over during unexpected winds with average speeds of 40 knots and unknown gust levels. The dent in the antenna and its skirt were banged out and more weight was added to its pedestal. The equipment has operated satisfactorily since that date.

The next piece of equipment to be described is used for the detection of flocks of large migrating water-fowl such as geese. It is based upon the electronic counter developed in Denmark but has been modified for our particular use. The equipment counts the number of flocks in a selected sector of the coverage of an air traffic control surveillance radar. Expansion to several sectors in an operational equipment is obtained by duplication of some of the circuits. The overall block diagram is shown in Fig. 8. One change has been made to this block diagram. Based on our increasing knowledge of several Canadian ATC radars, it has become apparent that they are operated with the antenna beam at a low angle of elevation in order to detect low flying aircraft. In consequence, the permanent echo region is extensive and the returns in these regions are very strong. Consequently, we have given up on the idea of using a separate logarithmic receiver connected to the radar's preamplifier. Instead, the same integrated MTI used for the controller's displays is employed. In general we have found that the maintenance on the sites is good and the quality of the integrated MTI video has been excellent.

Since my presentation last year, four circuits have been added. One is a circuit which provides counts of flocks directly to the controller. Formerly, he was required to read a chart in order to determine this number. A long pulse discriminator has been added which reduces the number of false counts when precipitation returns are obtained in the sector. A PRF discriminator has been added in order to reduce interference from an adjacent radar operating in the same frequency band. Provision has also been made to transmit the data to a smaller remote display unit. Built into this remote display unit is a circuit which provides an audible alarm if the flock count exceeds a pre-determined number. In the earlier presentation, charts were provided to the controller to interpret the

...... 4.

electronic count in terms of number of flocks and the probability of a bird strike. With the newer circuits, the need of these charts is questionable. The audible alarm will tell the controller when the situation is becoming dangerous and since he knows the sector's shape and position and the number of flocks in it, he can readily visualize exactly how dangerous the situation is at any time.

The equipment has been operated during the last two spring migration seasons. Fig. 9 shows the results obtained at Winnipeg last year during the snow goose migration. Three labels are shown on the y-axis. However, they are all related and only the second one need concern us--the flock density per square nautical mile. The maximum reached was 0.24 or about 1 flock every 4 square nautical miles. If an aircraft is assumed to have the frontal dimensions of 600 sq. ft. (i.e., a 707/DC-8 with its flaps and landing gear down) and each flock consists of 100 birds on the average; then the probability of a strike is about 1.23 per 10,000 miles flown below 5000 feet.

During this year's spring migration, the equipment has been operated at Ottawa during the migration of Canada Geese. The results have not yet been analyzed in detail. However, on what is thought to be a typical day, the flock density was .06 per nautical square mile which is about one-quarter that measured at Winnipeg. However, it appears that this density of .06 was equalled or exceeded on 6 or 7 days. When the Ottawa results have been analyzed in detail, a meeting will be held with air traffic control in order to determine whether they have an operational use for this equipment. One air traffic control region in Canada has asked for an equipment which will provide both position and height on all flocks in the immediate vicinity of the airport. This will require a much more expensive equipment, but this can be done. It remains for air traffic control to decide whether they want that sophistication and to find the funds to realize the decision.

With both equipments there has been no maintenance problems after the initial set-up. As is to be expected, initial set-up times are somewhat protracted as one attempts to find the best method. Once that method has been found, the time should be much reduced on similar equipments.

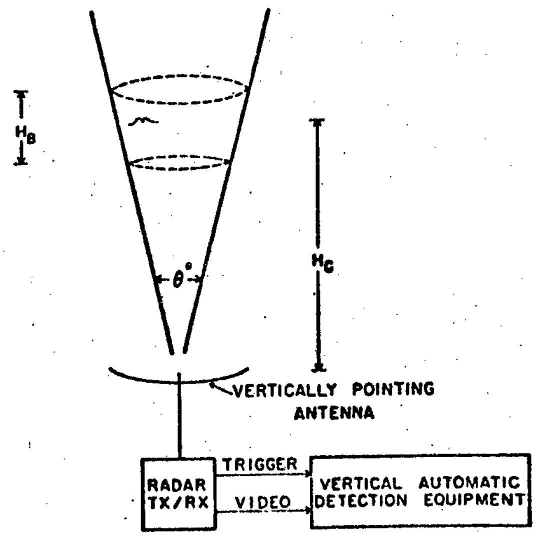


Fig. 1. Vertical Automatic Detection System

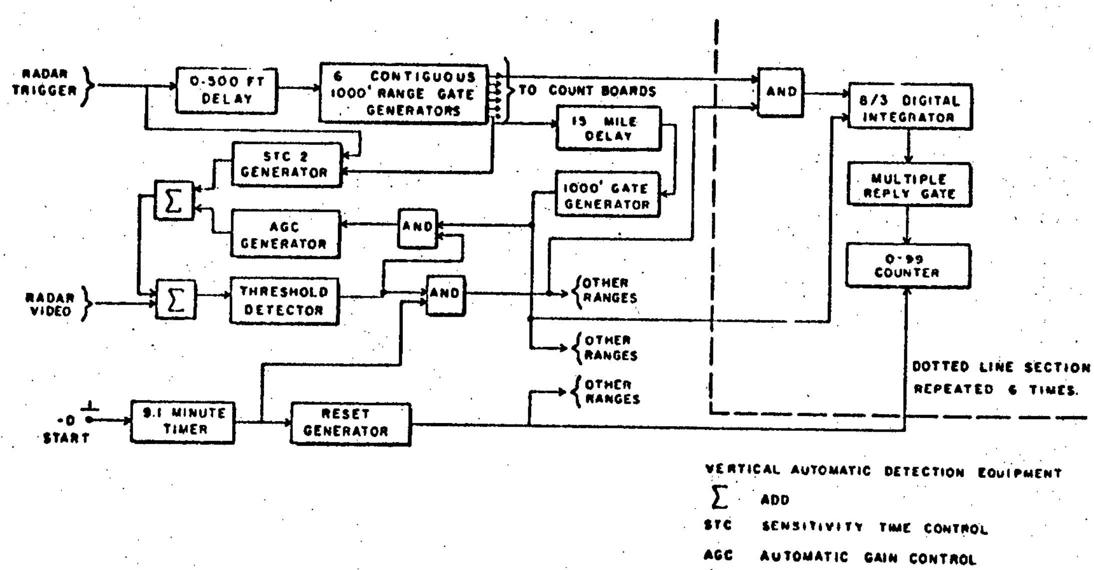


Fig. 2. Vertical Automatic Detection Equipment

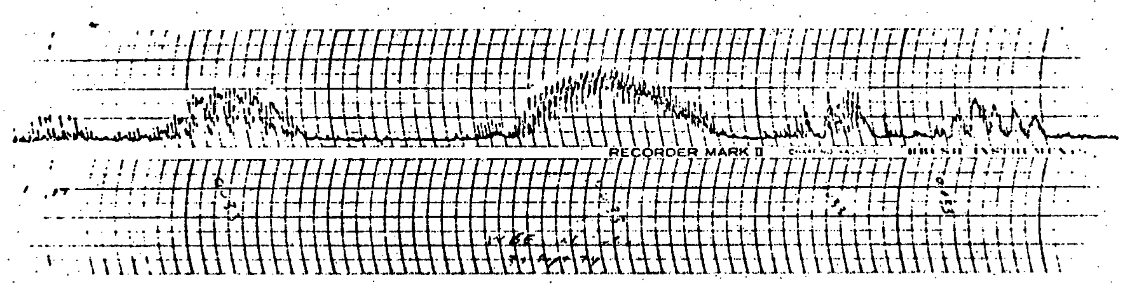


Fig. 3. Typical Wing Beats from Vertical Radar

BIRD COUNT/CHANNEL
VADE PROGRAM F84--100575

DATE = 3-4/10/74

TIME	CHANNEL NUMBER					
GMT	1	2	3	4	5	6
2310	0	0	0	0	0	0
2319	0	0	0	1	0	0
2329	0	1	0	1	0	0
2338	0	0	3	2	3	0
2348	0	0	3	6	2	0
0	0	0	2	2	2	0
10	0	0	3	3	2	1
19	0	0	9	2	3	0
29	0	0	4	10	4	0
38	0	1	3	8	3	0
48	0	1	5	2	2	0
58	0	0	5	9	4	0
109	0	2	5	9	6	0
119	0	0	7	17	4	3
138	0	11	14	21	5	2
147	0	19	26	15	12	1
157	0	19	19	14	6	0
206	3	9	18	23	7	3
216	0	13	18	12	8	1
225	0	20	13	12	5	1
235	0	12	16	12	3	0
244	2	8	20	19	4	3
253	1	26	16	6	2	1
303	0	13	17	6	2	2
312	1	13	15	5	5	1
322	1	11	12	7	2	0

Fig. 4. Bird Counts per Channel, 3-4/10/74

BIRD MIGRATION TRAFFIC RATE/NAUTICAL MILE FRONT/HOUR
VADE PROGRAM PR4--10057S

DATE = 3-4/10/74
ANTENNA BEAMWIDTH = 1.1 DEGREES
COUNT TIME = 9.1 MINUTES

TIME GMT	MEAN HEIGHT IN FEET (ASL) 1000	2000	3000	4000	5000	6000	TOTAL
2310	0	0	0	0	0	0	0
2319	0	0	0	569	0	0	569
2329	0	1234	0	569	0	0	1803
2338	0	0	2365	1147	1374	0	4886
2348	0	0	2365	3561	907	0	6833
0	0	0	1566	1147	907	0	3620
10	0	0	2365	1736	907	371	5378
19	0	0	7385	1147	1374	0	9906
29	0	0	3174	6149	1851	0	11174
38	0	1234	2365	4832	1374	0	9805
48	0	1234	3994	1147	907	0	7281
58	0	0	3994	5485	1851	0	11330
109	0	2479	3994	5485	2836	0	14794
119	0	0	5666	11155	1851	1139	19812
138	0	14224	11892	14329	2339	750	43533
147	0	25555	24123	9657	6063	371	65768
157	0	25555	16727	8929	2836	0	54048
206	9021	11527	15732	16013	3345	1139	56777
216	0	16974	15732	7514	3865	371	44455
225	0	27035	10965	7514	2339	371	48223
235	0	15592	13784	7514	1374	0	38265
244	5997	10197	17737	12711	1851	1139	49633
253	2990	36242	13784	3561	907	371	57855
303	0	16974	14751	3561	907	750	36944
312	2990	16974	12831	2942	2339	371	38447
322	2990	14224	10051	4191	907	0	32364

Fig. 5. Migration Traffic Rate, 3-4/10/74

BIRD STRIKE PROBABILITY/NAUTICAL MILE FLOWN
VADE. PTS. 41074

DATE = 3-4/10/74
ANTENNA BEAMWIDTH = 1.1 DEGREES
FRONTAL CROSS-SECTION OF AIRCRAFT = 10 SQ.FT.
ASSUMED VELOCITY OF BIRDS = 25 KNOTS
COUNT TIME = 9.1 MINUTES

TIME GMT	1000	2000	MEAN HEIGHT IN FEET (ASL) 3000	4000	5000	6000
2310	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2319	0.00E+00	0.00E+00	0.00E+00	3.74E-05	0.00E+00	0.00E+00
2329	0.00E+00	8.12E-05	0.00E+00	3.74E-05	0.00E+00	0.00E+00
2338	0.00E+00	0.00E+00	1.56E-04	7.55E-05	9.04E-05	0.00E+00
2348	0.00E+00	0.00E+00	1.56E-04	2.34E-04	5.96E-05	0.00E+00
0	0.00E+00	0.00E+00	1.03E-04	7.55E-05	5.96E-05	0.00E+00
10	0.00E+00	0.00E+00	1.56E-04	1.14E-04	5.96E-05	2.44E-05
19	0.00E+00	0.00E+00	4.86E-04	7.55E-05	9.04E-05	0.00E+00
29	0.00E+00	0.00E+00	2.09E-04	4.05E-04	1.22E-04	0.00E+00
38	0.00E+00	8.12E-05	1.56E-04	3.10E-04	9.04E-05	0.00E+00
48	0.00E+00	8.12E-05	2.63E-04	7.55E-05	5.96E-05	0.00E+00
58	0.00E+00	0.00E+00	2.63E-04	3.61E-04	1.22E-04	0.00E+00
109	0.00E+00	1.63E-04	2.63E-04	3.61E-04	1.87E-04	0.00E+00
119	0.00E+00	0.00E+00	3.73E-04	7.34E-04	1.22E-04	7.50E-05
138	0.00E+00	9.36E-04	7.82E-04	9.43E-04	1.54E-04	4.94E-05
147	0.00E+00	1.65E-03	1.59E-03	6.35E-04	3.99E-04	2.44E-05
157	0.00E+00	1.68E-03	1.10E-03	5.87E-04	1.87E-04	0.00E+00
206	5.94E-04	7.50E-04	1.04E-03	1.05E-03	2.20E-04	7.50E-05
216	0.00E+00	1.12E-03	1.04E-03	4.94E-04	2.54E-04	2.44E-05
225	0.00E+00	1.78E-03	7.21E-04	4.94E-04	1.54E-04	2.44E-05
235	0.00E+00	1.03E-03	9.07E-04	4.94E-04	9.04E-05	0.00E+00
244	3.95E-04	6.71E-04	1.17E-03	6.36E-04	1.22E-04	7.50E-05
253	1.97E-04	2.38E-03	9.07E-04	2.34E-04	5.96E-05	2.44E-05
303	0.00E+00	1.12E-03	9.71E-04	2.34E-04	5.96E-05	4.94E-05
312	1.97E-04	1.12E-03	8.44E-04	1.94E-04	1.54E-04	2.44E-05
322	1.97E-04	9.36E-04	6.61E-04	2.76E-04	5.96E-05	0.00E+00

Fig. 6. Bird Strike Probability, 3-4/10/74

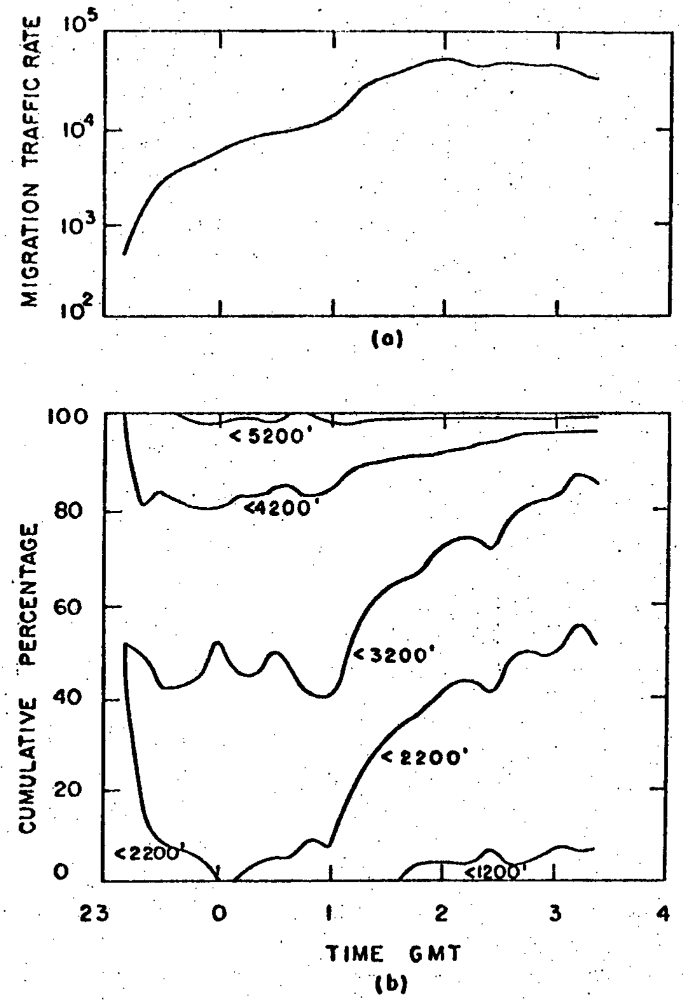


Fig. 7. Migration Traffic Rate and Height Distribution, 3-4/10/74

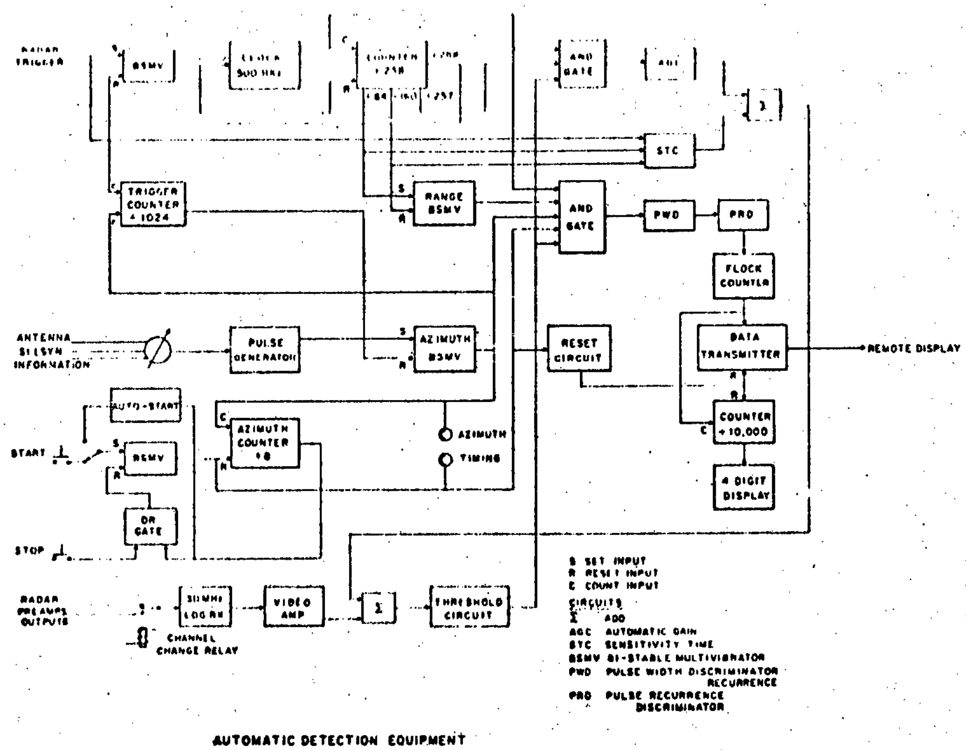


Fig. 8. Sector Automatic Detection Equipment

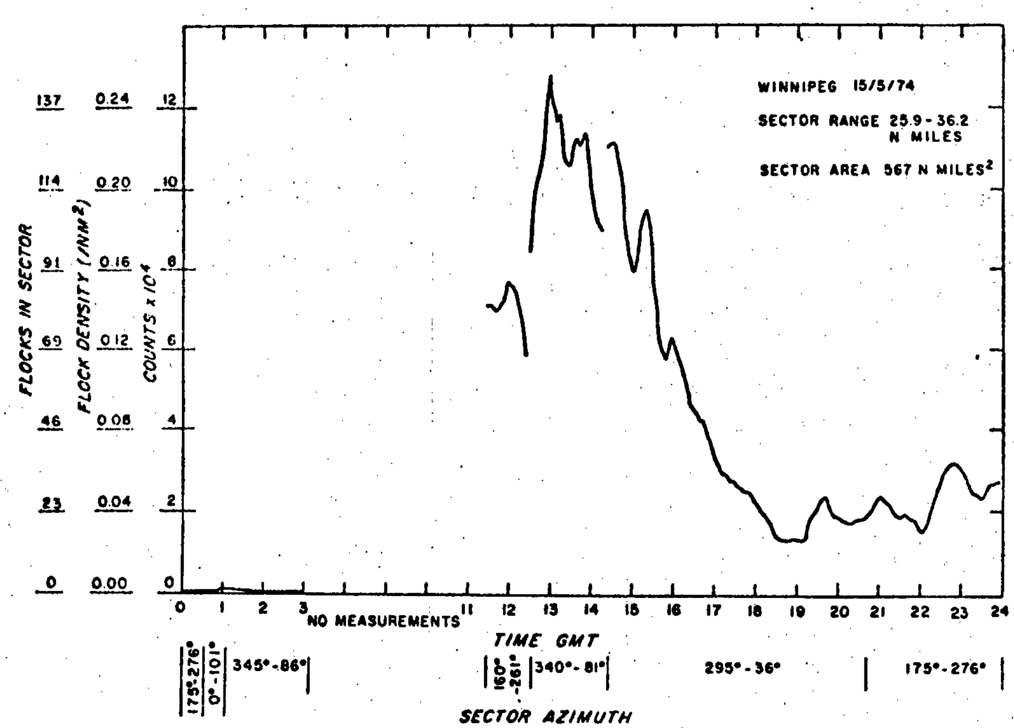


Fig. 9. Snow Goose Migration from SADE, 15/5/74

253

12 June 1975

The bird strike problem from a technical point of view by A Roed, The Aeronautical Research Institute of Sweden

Gentlemen, it is a pleasure to have the opportunity to come to the tenth BSCE meeting and talk about bird strikes from a technical point of view.

I shall not bother you with technical details but rather look at the problem in a broad way.

Man's desire to fly like the birds can, as you well know, be traced back to mythology. When he finally succeeded, it did, however, take him a long time to realize that he might meet one of his "bird buddies" in the air - head on.

In the bird strike case, as in many other cases of flight safety, it appears that we must have someone dead before we wake up to realize that something can and should be done before accidents happen. This is true both for aircraft and airport design.

Why does it take such a long time between the discovery of a danger and the technical solution of the problem? The answer is difficult to give, but it is not that the aircraft or airport engineer does not care. Part of the explanation may be found in basic engineering education and in the traditional way of developing airplanes.

First of all, in aviation as in all types of engineering, you need a set of standards to work to. Therefore, for design purposes we use a standard atmosphere with standard pressures and temperatures and standard variations with altitude. In this atmosphere there is no wind, no rain, no snow, no fog, no night, no birds - no operational problems?! It is surprising how little is being taught about practical operational problems in schools and how long time it takes a person in post-school practical work to realize that there is more to aeronautical engineering than basic aerodynamics, basic structures, basic engine design (with uniform air intake flow), etc. Better training in practical problems is required.

Secondly, there is a tendency in aircraft manufacture for the various departments to isolate themselves to some degree. Therefore, you may find designs that are good from some points of view but poor in other respects. A side-by-side design with a large unobstructed canopy may have many advantages as far as flight training is concerned, but it is not a good "bird strike design". There is a real need for people who can handle the total problem area and optimize from more than one or two points of view.

Thirdly, it is not easy to develop a new aeroplane. From the day the configuration is chosen and the manufacturing schedule has been selected until some years past the first flight date you have your time filled with work and problems to solve. Sometimes weeks appear to consist of Mondays and Fridays only. Monday is the day you say: "This new week I will do the job" - and on Friday you think: "Oh, well, we will catch up next week, but what to hell happened to Tuesday, Wednesday and Thursday".

AD F 616 213

In this environment you must have a very strong argument if you want to do something new or to introduce new basic design requirements. And, you must come early with your suggestions, because after a short time the tools are made and then it becomes extremely difficult to make changes, due to the high costs involved. (To me the time it takes to make tools has often appeared to be unbelievably short - sometimes I think tools are selected before the configuration.)

The question then comes up: "Do you have good arguments for design changes from a bird strike point of view?" Someone may say that you do not. Accident statistics may, for instance, show that the real safety problems today concern human factors and landings (in civil aviation) and that the money for improvement should be invested here. This is not a very good argument. It is better to consider separately the various problems and the cost for their solution. One may then find that the bird strike problem falls in the rather simple design deficiency class, where solutions are not necessarily difficult to find and where the cost of the solutions may be much smaller than the cost of doing nothing. In such a case you have a good argument for design changes disregarding the magnitude of the specific problem in relation to the total safety picture. Contrasting this type of safety problems you may have larger problems that are more psychological in nature, where it may be more difficult to show convincing cost effectiveness in the solution. It is not necessarily the size of the problem that decides when it should be attacked.

Fortunately, the continuous work of dedicated people wears through the resistance to design modifications, and in the bird strike case new and better design requirements are appearing and resulting in improved structures and engines.

However, we both should and can go much further than we have today, both in airport and aircraft design, before we can feel satisfied. There is, for instance, no reason to believe that ongoing canopy research, such as the American bird strike tests at sea level supersonic speeds, will not result in canopy glass that can take any sensible bird strike. Before we reach this goal, we have to solve many optical, glass scratching and glass shatter problems and we have to solve the problem of how to get out of an aircraft (military) with a jammed canopy having an "infinitely" strong glass.

New materials, composites for instance, will emerge that will make it possible to design wing leading edges meeting the combined requirements of high lift, excellent antiicing and good bird strike resistance. The need to do so will increase as the efficiency of leading edge devices goes up and the requirement for all-weather flight with excellent leading edge deicing becomes a necessity. This is a typical aerodynamics-design-manufacture-maintenance-operation problem that must be solved.

However, even if we make the improved designs, we cannot relax the work required to maintain low bird strike hazards in operation, because, even if modern engines can take a very high "bird beating" without disintegrating, we still as a rule have to discontinue the

flight and remove the engine for inspection and repair when a bird strike is indicated. This is very expensive, especially in case of a large airplane. There is no immediate hope for damage-free bird ingestion in engines.

Even if we should be able to solve the damage problem, we still have to consider the flame-out problem, especially for smaller engines. The increased use of executive jets and turboprop aircraft at all types of airfields indicates that this problem may increase.

Thus, from a technical point of view the good work must continue. International cooperation will reduce the costs of doing so by making sharing of material development, design methods and test results possible. Also, considerable cost reductions for improved airframe design may be obtained in the future by means of new computerized stress calculations that eliminate the need for bird strike tests. There is still some way to go before high speed flight at low levels is technically safe with regard to bird strikes.

AD F 616 214

HOW MANY BIRDS ARE THERE IN SWEDEN?

Staffan Ulfstrand

Department of Animal Ecology, Helgonav 5, S-223 62 Lund, Sweden.

From theoretical as well as practical aspects data about the size of bird populations over large areas are most desirable and useful though rarely available. Thus, for instance, quantitative ornithology patently has a role to play in our joint efforts to minimize the hazards of bird collisions to aircraft.

It is evidently impossible to count accurately all the birds in Sweden. Different types of sampling programmes are currently being developed and tested (Svensson 1974) with the aim of estimating the absolute numbers of breeding birds in this country and, above all, the annual fluctuations of bird populations. However, many species will not be encompassed in this programme which, moreover, so far has yielded only preliminary published results. Notwithstanding the amount of census work, bird numbers cannot possibly be more than crudely estimated, since their populations change from day to day, from season to season and from year to year, owing to the balance between rates of birth and death and of immigration and emigration.

Actually, for many purposes, we do not require estimates better than to the right order of magnitude, and it is my contention that we can estimate the size of most Swedish bird populations considerably better than that; for many species the following figures, although so-called "guesstimates", are presumably correct within a factor of 2.

Let us first look at the Swedish breeding bird fauna which consists of about 240 species. Two different approaches may be used. First, the preliminary census data published by Svensson (1974) may be used. They are especially applicable to the abundant small birds in terrestrial habitats. Most bird communities censused were found to consist of 250 to 750 breeding pairs km^{-2}, although the range of density values reached from below 50 to above 1500 pairs km^{-2}. However, the areas censused are not representative for the whole country, since rich habitats have been preferred by the ornithologists, while there are disproportionately few data from moors, dry pine forests, and agricultural land. Therefore, we have to reduce the density figure indicated by Svensson's data. Let us put

Sweden's area to 450 000 km^{-2}: 200 pairs km^{-2} would seem a fair estimate corresponding to a total Swedish bird population of 90 mill. pairs.

Second, we may try to estimate the total population size for each species using density figures and results of country-wide inventories when available and filling in with estimates for the rest. I have tried this exercise, and the detailed result is presented in a book by Thomas Alerstam, Johnny Karlsson and myself (1975). According to this approach the total Swedish breeding avifauna was found to consist of approximately 110 mill. pairs.

Thus, let us assume that about 100 mill. bird pairs breed in Sweden.

A great majority of Sweden's birds are migratory and depart from this country after having completed their reproduction. There are no density figures for the winter bird fauna, so we can use only the second approach described above, viz., estimating the size of each population and adding over all species. This has been tried and produced an estimate of 28 mill. birds being present in Sweden at midwinter. Since large and heavy birds more often are stationary than small birds (Ulfstrand 1974), the total weight of the bird fauna is less reduced in winter than are numbers of individuals.

If we wish to estimate the number of birds taking part in the autumn migration in southern Sweden, we have of course to add the year's production of young to the number of breeding birds. We have assumed that there are 100 mill. breeding pairs, i.e. 200 mill. individual birds. A reasonable estimate may be 3 young per pair surviving at the time for the autumn migration. Many species of course have much larger clutches than so, but the early postbreeding mortality is often severe. Accepting the estimate, we arrive at a figure of 500 mill. birds departing from Sweden each autumn.

A very important item in our attempted avian budget is the number of birds that derive from other geographic areas, especially Finland and the western part of the USSR, and pass through southern Sweden during their autumn migration. We know that a tremendous number of birds do cross the Baltic, mainly over the Åland archipelago and further south, and the fame of Ottenby bird station on the island of Öland is based almost entirely on migrating birds from east of the Baltic. In the absence of data, we have as always to attempt to make a fair estimate, although one that is much more uncertain than the rest in this paper, and assume that the trans-Baltic migration may add another 50 percent

to the number of birds migrating through southern Sweden bringing the total to 750 mill. birds.

With reference to bird strike hazards it is of course important to estimate how many birds migrate by night and by day, respectively. Sweden's most abundant bird, the Willow Warbler *Phylloscopus trochilus*, only migrates by night, and so do many other small birds bound for more or less distant goals. A very large group of birds migrate both by day and by night, such as most waders and ducks and many passerines, for example the thrushes *Turdus* and pipits *Anthus*. The second most numerous bird in this country, the Chaffinch *Fringilla coelebs*, mainly migrates in the day, and the same applies to many other finches, Starling *Sturnus vulgaris*, Wood Pigeon *Columba palumbus*, swallows and martins (Hirundinidae), Swift *Apus apus*, Crow *Corvus corone* and its relatives, and all birds of prey. Considering the enormous quantities of Willow Warblers and certain other small passerines that migrate exclusively by night, there can be no doubt that the majority of Swedish birds migrate during the dark hours. Let us assume that 2/3 of the birds are nocturnal and 1/3 diurnal migrants.

Long ago studies of the visible migration demonstrated that intense diurnal migration was restricted to a few days each autumn (Rudebeck 1950). This has also been confirmed for high-altitude migration with the use of radar (e.g., Alerstam & Ulfstrand 1972). A very large proportion of all migrants thus will be recorded on a few occasions, while on most days little migration takes place. Recent work using radar as the chief tool has shown that the same applies to nocturnal migration (Alerstam et al. 1973). Therefore, the 750 mill. birds assumed to be in the air over southern Sweden each autumn are far from randomly or evenly dispersed through the migration season. On the contrary, they are concentrated to a small number of occasions. Most migratory birds depart from Sweden between August 15 and November 31. Let us assume that 90 percent of all nocturnal migrants are concentrated to 10 nights during that period: this yields an estimate of about 50 mill. birds being on the move on a single optimal night. The corresponding calculation for the diurnal migrants leads to half this figure. It is interesting to compare these astounding figures with the number of birds actually seen and recorded at our bird stations. At Falsterbo, which is justly famed as one of the world's outstanding places for watching bird migration,

the autumn's total rarely exceeds 1 mill. birds (Ulfstrand et al. 1974), and at Ottenby the figure is much lower still (Edelstam 1972).

Since the migrating birds tend to fly at a fairly low altitude, especially during the day, the density of birds in the air may sometimes be considerable. As pointed out, however, intense migration is concentrated to periods of relatively short duration. Since the migratory activity is correlated with predictable meteorological conditions, different for different species or species groups, it seems to be both meaningful and possible to develop a forecasting system for fluctuations in space and time of bird migration intensity.

References

Alerstam, T., Lindgren, A., Nilsson, S. G. & Ulfstrand, S. 1973. Nocturnal passerine migration and cold front passages in autumn - a combined radar and field study. - Ornis Scand. 4: 103-111.

Alerstam, T. & Ulfstrand, S. 1972. Radar and field observations of diurnal bird migration in S. Sweden in autumn 1971. - Ornis Scand. 3: 99-139.

Alerstam, T., Karlsson, J. & Ulfstrand, S. 1975. Fåglar och flyg. Luftfartsverket, Stockholm.

Edelstam, C. 1972. The visible migration of birds at Ottenby, Sweden. - Vår Fågelv. Suppl. 7: 1-360.

Rudebeck, G. 1950. Studies on bird migration. - Vår Fågelv. Suppl. 1: 1-148.

Svensson, S. 1974. Svenska häckfågeltaxeringen - den fortlöpande övervakningen av fågelfaunan fortsätter. - Vår Fågelv. 33: 92-99.

Ulfstrand, S. 1974. Den skånska fågelfaunans artsammansättning under vinter och sommar - några ekologiska jämförelser. - Anser 13: 225-240.

Ulfstrand, S., Roos, G., Alerstam, T. & Österdahl, L. 1974. Visible bird migration at Falsterbo. Sweden. - Vår Fågelv. Suppl. 8: I-XLIV + 1-245.

AD F 616 215

29th July 1975

Current Activity Concerning the U.S. Bird/Plane Strike Problem

by

John L. Seubert
U.S. Fish & Wildlife Service

Thank you Mr. Chairman

My purpose today is to review very briefly programs in the United States that are concerned with the bird/aircraft strike problem.

The Federal Aviation Administration, the U.S. Air Force, and the U.S. Fish and Wildlife Service conduct research and management programs on the bird/ strike problem. Officially, I represent the Fish and Wildlife Service, and not the other concerned agencies. Today I will bring you up-to-date about events that involve all three organizations.

A. Yearly bird/plane strike data are collected and analyzed by both civil and Air Force interests.

B. The FAA has issued Order #5200.5 to give aerodrome operators guidance concerning sanitary landfills on or near aerodromes.

C. The National Transportation Safety Board has recommended to the FAA that special attention be given to the bird hazard to large by-pass fan jet engines.

D. The U.S. Air Force conducts management and research both in-house and through other agencies, such as the Fish and Wildlife Service. The research includes several studies, briefly as follows:

   1. The recent completion of a manual to show radar operation how best to detect bird targets.
   2. The initiation of research to develop a model for predicting when blackbirds and starlings enter and leave roosts.
   3. Research utilizing radar data to develop a model for predicting bird migration in Southwestern United States.
   4. Planned research to study the attractiveness of milled or shredded garbage to gulls and other birds.

E. The Fish and Wildlife Service, my employer, does research and management on agricultural, safety, health, and nuisance problems caused by blackbirds and starlings--species that can be hazards to aircraft. We recently completed another survey of major blackbird/starling roosts in the United States. This and past surveys indicate that the total U.S. winter population of these species approximates 1/2 billion birds. Since roosts of these birds can create problems, we are studying ways of changing roosting habitat to make it unattractive.

   Because of recent publicity and concern about large blackbird/starling roosts in the United States, I will end this presentation with a very short film about a very large blackbird roost that was located at Ft. Campbell, Kentucky, this past winter. The purpose of showing the film is to give you some idea of the large numbers of birds involved. This is a Department of Defense film. You will also see some film on the Peachtree Airport at Atlanta, Georgia, where a Lear Jet crashed a few years ago because of cowbirds.

CONTENTS

253

ADF 616 216

Note: This book about the bird hazards to aircraft is now in production and will be available during the autumn of 1975. The full title is: "Bird Hazards to Aircraft. Problems and Prevention of Bird/Aircraft Collisions".

7. <u>Subjects under examination by the Committee</u>

7.1 Review of the Terms of Reference of the BSCE

7.2 Editing Committee, BSCE

7.2.1 Terms of Reference of the Editing Committee

7.2.2 Information about working papers (WP/6, Appendix B)

7.3 Work programs of the working groups, BSCE

7.4 Proposal for a new working group

BSCE/10
12 June 1975

Review of the Terms of Reference of the BSCE

The 10th Meeting of the BSCE reviewed its original terms of reference which had been agreed by the representatives of National Bird Strike Committees and experts from a number of European States at its First Meeting in 1966 and had been amended by subsequent meetings of the European Bird Strike Committee. It was found that these terms of reference needed further up-dating in the light of experience. After some discussion the Meeting agreed that the following should constitute the terms of reference of the BSCE from here on.

"The Bird Strike Committee Europe

should:

a) collect, analyze and circulate to all concerned data and information related to the bird strike problem in the European Region;

Note: This data and information should include the following:

1. Civil and/or military data collections and results of analyses on bird strikes to aircraft.

2. Results of any studies or examinations undertaken by States in the various fields related to the bird problem.

3. Any information available in the field of design and structural testing of airframes related to their resistance to birdstrikes.

4. Any other information having a bearing on the bird strike question and the adding to the solution of the various problems involved.

b) study and develop methods to control the presence of birds on and near aerodromes;

c) investigate electro-magnetic wave sensing methods (e.g.: radar, invisible light, etc) for observing bird movements;

d) develop procedures for the timely warning of pilots concerned where the existance of a bird hazard has positively been established;

e) develop procedures, if appropriate, for the initiation by air traffic control of avoiding action where the existance of a bird hazard has positively been established;

269

f) develop procedures enabling a quick and reliable exchange of messages regarding bird hazard warnings;

g) develop any material (e.g.: maps, back-ground information, etc) intended for inclusion in Aeronautical Information Publications;

h) aim at a uniform application, throughout the European Region, of the methods and procedures and the use of material developed in accordance with b) to g) above, provided suitable trials have proved their feasibility, and monitor developments in this respect."

Terms of Reference of the Editing Committee, BSCE

1. An Editing Committee is appointed as a policy steering committee to assist the Chairman of the BSCE between and during Meetings. The main tasks of the Editing Committee are:

   a) study, evaluate and select papers to be presented to the Working Groups and the Plenary Meeting

   b) during each BSCE Meeting participate in preparing recommendations, proposals for text for inclusion in the Report, and, where necessary, any other papers of a general nature

   c) at the end of each BSCE Meeting participate in preparing the Report of the meeting and prepare the follow-up action of recommendations

   d) assist the BSCE Chairman in formulating BSCE Policy Statements

2. The Editing Committee should consist of:

   (i) the BSCE Chairman

   (ii) the previous BSCE Chairman, if possible

   (iii) the Chairman of each BSCE Working Group

   (iv) the observer from ICAO

   (v) a representative of the host State

3. The BSCE Chairman acts also as the chairman of this committee and is entitled to call meetings of the Editing Committee as and when required during BSCE Meetings.

4. The conclusions of the Editing Committee should be presented to the Plenary Meeting of the BSCE for action. Alternatively the members of the BSCE should be kept informed of the activity of the Editing Committee between full meetings of the BSCE.

A P P E N D I X B

Information about Working Papers

Division of working papers into groups.

It is the opinion of the chairman and of the Swedish Editing Committee for BSCE 10 that it could be suitable to divide the working papers of the Meeting into groups in accordance with their affiliations to the different sectors of problems connected with the conflicting movements of aircrafts and birds. The groups are to some extent, but not completely, connected with the subjects of the BSCE working groups. The division has been made according to the following analyse in survey form of the Bird Strike Problem.

Definition of the Problem

I. related to Birds

II. related to Aircraft

III. related to Man
- pilot
- controller
- airport staff
- air safety people
- scientist

I. Birds

1. How to detect them
   - a) Visual observations
   - b) Radar observations
   - c) Forecasts of migration/movements

2. How to avoid them
   - a) In the airfield
     - long term planning (habitat modifications)
     - short term planning (scaring actions)
     - local information for airlines or airforces
   - b) Information on their movements
     - AIP
     - internal information and briefing

II. Aircraft

1. Bird strike statistics

2. Structure improvements
   - airframe
   - engine
   - canopy

III. Man

1. Pilot
   - a) Avoiding action
     - speed, manaeuvres
     - height
     - light
   - b) Reports of bird strikes

2. Controller

   a) Phraseology - guiding and informing the air traffic
   b) Radar observations

3. Airport staff - Executing of habitat modifications and scaring actions

4. Air safety personnell (including airlines) - Preparing rules and recommendations. Education. Training programmes

5. Scientist

a) Ornithologist	Special studies
b) Meteorologist	Forecasting programmes
c) Physicist	Scaring equipments

When receiving papers the editing committee will arrange them in groups according to the theme of the paper. As far as possible papers dealing with the same type of problems will be dealt with in close connection during the meeting.

The editing committee will also draw the attention to the fact that some of the above mentioned sectors of problems have not previosly been subjects for necessary interest. For this reason it is highly desirable that papers dealing with the pilots and the controllers problems as well as with aircraft structural problems will be delivered to the meeting. - In the past rather few people within these cathegories have attended the BSCE-meetings and therefore the organizing committee will encourage a higher attendance from them.

)))

Note: This information about working papers is supposed to be used by the Editing Committee, BSCE and the Editing Committee of the arranging country when studying, evaluating and selecting papers to be presented to the Working Groups and the Plenary Meeting.

WORK PROGRAMS OF WORKING GROUPS OF THE BSCE

1) W.G. BIRD MOVEMENT (chairman: Dr. J. Hild)

Study of bird concentrations and movements and the drawing up of special maps for the information of pilots and air traffic services.

2) W.G. COMMUNICATIONS (chairman: V.E. Ferry)

Study of all problems relating to the transmission of information on bird movements which could present a hazard to aviation and the provision of such information to air traffic services.

3) W.G. RADAR (chairman: E.W. Houghton)

Dealing with matters associated with the use of radar in the surveillance, identification, and assessment of bird movements.

The work of the Group embraces the evaluation of the radar properties of birds of specific radar equipments and techniques, of improvements in design and data handling, and also of "best" ways of operating radars.

4) W.G. AERODROMES (chairman:Dr. W. Keil)

a) Preparation of general recommendations to reduce the bird problems on and around aerodromes.

b) Coordination of bird control research activities between States concerned.

5) W.G. ANALYSIS (chairman: J. Thorpe)

Development of a standardised format for analyses based on the data contained in Bird Strike Reporting forms.

6) W.G. STRUCTURAL TESTING (chairman: not yet known)

(i) To exchange information on the results obtained from:

(a) Bird impact research testing of materials, structural specimens, windscreens etc.

(b) Tests to meet compliance with Civil Airworthiness requirements

(ii) To discuss and evaluate the information in order to provide design guidance material for satisfactory methods of producing bird impact resistant structures, windscreens, etc.

(iii) To exchange information on analytical work.

(iv) To establish liason on future research programmes in order to avoid duplication.

925

BIRD STRIKE COMMITTEE EUROPE

Comments by the Chairman BSCE on a proposal for a new Working Group

1 <u>General rule</u>

1.1 Before forming a new Group, a clear answer must be found to two fundamental questions.

(i) Is enough knowledge available?

(ii) Are enough people ready to collaborate?

1.2 After the answers are obtained from the committee members, or their duly appointed representatives, a study must be made by the Editing Committee (in that case acting as a Steering Committee) in order to consider whether to

(i) call a "task-force" or "evaluation body" inside the Working Group closely related to the subject of proposal

(ii) or form a new Group by circulating a document asking for collaboration within BSCE or abroad.

1.3 Care must be taken that the new Group does not duplicate any existing working group of another international organisation.

2 <u>Comments on the proposal to form a Structural Testing Working Group.</u>

2.1 BSCE is working on a voluntary basis without any constraint from States or International organisations. Experts attending plenary sessions or working group meetings, are seldom representing Authorities and are without any power to enforce recommendations set forth by BSCE unless accepted deliberately by States on a purely individual basis.

2.2 The objective of the proposed Structures Group may involve strong opposition from manufacturers unless states endorse Working Group Terms of reference.

2.3 Further complications could be expected when full knowledge of military aircraft strikes becomes available to the BSCE and an inhibiting effect could be expected from states not willing to publish any more information on bird strikes because of the operational aspects of some of them.

2.4 However the importance of air safety is predominant and justifies completely the formation of a new Group under carefully selected conditions.

3 <u>Suggestions</u>

3.1 That all countries co-operating in BSCE should be consulted on the whereabouts of the new Group.

3.2 Information to be forwarded to appropriate ICAO Airworthiness section as soon as the survey is finished.

3.3 Work being restricted to Civil aircraft as a first step, with the Working Group accepting Air Force specialists as observers.

8. <u>Co-operation with other international organizations</u>

8.1 Co-operation with ICAO, a progress report.

8.2 The problems of aviation ornithology at the "First All-Union Conference on bird migration (Moscow, 2-5 June 1975).

2 July 1975

COOPERATION WITH ICAO, A PROGRESS REPORT

1. Introduction

1.1 Since many years, the BSCE has discussed, tested and adopted a number of methods to prevent bird hazards from becoming a serious threat to aviation. At our last meeting, it had been stated that continuous contact and cooperation with international Organizations should be maintained for the benefit of all.

My aim was to continue work on the basis of what has been achieved with regard to :

a) the exchange of information on bird activities ;

b) the establishment of a new regional bird strike committee outside Europe ; and

c) the role of the BSCE within International Aviation.

2. Information on birds activities

2.1 This item deals mainly with content and distribution of information on bird hazards as far as they concern the Aeronautical Information Services. These services distribute information through publications containing information of a permanent character essential to air navigation as well as by means of messages containing temporary information of direct operational significance.

Permanent Information

2.2 All relevant information and guidance material concerning environmental management, research and detection methods which are of interest both to ornithologists and to airport management have been published in the ICAO Aerodrome Manual (Doc 7920 - AN/865, Part 5, Volume II refers).

By Information Circular n° 32/BSCE of 14 January 1975 members were asked for comments or proposals for amendment to this document. In the absence of replies, the BSCE did not propose any changes to the Aerodrome Manual at this time.

2.3 The publication by States of information of a more permanent character concerning bird concentration in the vicinity of aerodromes and bird migrations has been covered by Amendment 15 to Annex 15 applicable as of 23 May 1974 (Annex 15, Appendix 1, paragraphs 2.0.6 and 5.6 as well as the AIS Manual (Doc 8126 - AN/872/2), Appendix G, pages AGA 0-2.1, RAC 6.1, 6.3, and 6.4 refer).

.../...

The sample charts published correspond to those already used within the BSCE based on work undertaken by Doctor Hild's team.

Temporary information

2.4 A coded format already used by BSCE for the dissemination of temporary bird hazard information and designated "BIRDTAM" had been proposed by the EUM VI RAN Meeting (1971) (Recommendation 16/16 refers). The Air Navigation Commission, however, unconvinced of the need for concepts such as BIRDTAM and noting the existing provisions in Annex 15 paragraphs 5.5.2 and 5.5.3 and that the PANS-ABC (Doc 8400/3) would soon contain NOTAM Code groups UW, UY and UZ with significations which covered as much of the proposed information as was essential and could reliably be obtained , decided that NOTAM should invariably be distributed in series separately identified by letter as provided for in paragraph 5.4.1.1 of Annex 15.

Note : The NOTAM Code Groups mentioned above have the following meaning :

SECOND AND THIRD LETTER AFTER "Q" :

UW - Bird hazard

FOURTH AND FIFTH LETTER AFTER "Q" :

UY - Migration in progress .... (location of observation)....

....(date/time)....(species)....(direction of flight)....

....(height above the specified datum)

UZ - Concentration or local movement of .... (species)....

....(nature of movement) at .... (date/time)

2.5 With regard to the predetermined distribution system for NOTAM it should be noted that this matter is covered by paragraphs 5.3.3 and 5.3.4.3 of Annex 15.

2.6 In view of the above and bearing in mind that we should conform as far as possible to civil aviation rules, our messages related to bird hazards should be made in the form of NOTAMs and using the NOTAM code. I would therefore suggest that our efforts should be aimed at obtaining that change as soon as possible.

3. Establishment of a regional bird strike committee outside Europe

3.1 The Asia/Pacific Regional Air Navigation Meeting in 1973 adopted a recommendation asking for :

a) the organization of national bird strike committees in each State ;

.../...

b) the formation by States of a Regional Bird Strike Committee with the objective of providing assistance and guidance to each other ; and

c) that ICAO lend its support to the formation and activities of such a Regional Committee.

The Air Navigation Commission approved a) and b) of the Recommendation and requested the Secretary General to study and report on the feasibility of part c) before further action is taken.

3.2 ICAO has now explored the situation and consulted the States concerned. The replies have indicated that the bird hazard problem in the area was, in fact, not sufficiently significant to warrant the formation of a Regional Committee. It has however been agreed that during the present year an information seminar should be conducted at the ICAO Regional Office in Bangkok, with the assistance of the BSCE.

3.3 It should also be noted that this question will be raised by the French delegation to the CAR/SAM Regional Air Navigation Meeting planned for 1976.

4. <u>Relations with ICAO</u>

4.1 As regards the relationship of the BSCE with ICAO this has now been officially agreed in the following terms : "The BSCE acts in an advisory capacity to ICAO, working through the European Office of ICAO, on matters concerning the hazard to aviation caused by birds".

4.2 With regard to the establishment of a new "Structural Testing Working Group" inside BSCE, close contact was maintained with ICAO (see 9th BSCE Meeting). It was however found that this problem appeared not to require action by ICAO at this time.

4.3 For the future it is intended to develop suitable phraseology regarding bird hazards for use by controllers with the aim of its inclusion into the PANS-RAC (Doc 4444). Further action is planned for developing a proposal by the BSCE for an international agreed intensity scale for bird concentrations as shown on radar displays.

-:-:-:-:-:-

The Problems of aviation ornithology at the First All-Union Conference on bird migration(Moscow,2-5 June 1975)

V.E.Jacoby.USSR.

One of symposium of the bird migration coference,which had taken place in Moscow has been dedicated to the problem of migrating bird strikes.V.E.Jacoby in his report "Bird migration and aviation" has shown on the series of examples that the most serious danger is caused by migrating birds who appear at an airport and who see a plane a short distance for the first time.Shooting or other means of birds distruction are unsuitable.There were considered ways to prevent migrating bird strikes by means of deduction of their number at an airport with help of an active frightening,by creation of ecologically unattractive situation and by utilization of a radar in order to disclose and to forecast mass mird migration,dangerous for planes. A.I.Rogachev has reported how the airport metheorologists carry out the visual observations of bird migration,how these data are transmitted to the section of the aviation ornithology of the Coordination Counsil to study bird migration and orientation and how these data are used tO forecast mass bird migration and to prevent bird strikes..Y.A.Micheyev and A.I.Rogachev in their report "Ornithological protection of aviation flight security during bird migrations" have shown that combination of the visual and radar observation,utilization of the locall ornithologist's experience and the generalization of obtained information will make it possible to solve the problems of scientific and aviation applied nature.

L.F.Nazarenko and other ormithologists from Odessa State University have told about the results of the regional ornithological service activing to study bird migration and to prevent bird strikes at

South-West of the USSR.The comparison of data obtained by airo-visual accounts,by ringing and by visual observation with the data of meteorological situation has made it possible to create the map of migration ways and of mass seasonable bird accumulation and to forecast mass bird migration dangerous for a planes at the North-West coast of the Black Sea.M.Zhalakyavichus(Inst.Zool.& Parasithology Lituaniane Acad.of Sc.)has carried out the twenty-four hours photo registration of the MTI at airports survay radars in Vilnius(I5.IX-I.XI.74) and in Palanga(I5.IX-I5.XI.74).The intensive flight has been marked in the Palanga area over the Baltic Sea toward the South and Souyh-West at the altitude at 2-3 klm and at the 60-70 klm distance from the coast.The small sparrow-like birds have flown here at lower altitude and over the sea-coast.The flight in the Palanga area has been considerably greater than that in the Vilnius area and took place in the evening,during the night and within the first part of a day.Dr.Grun(GDR)has reported about the bird strikes problem in GDR.The most of the bird strikes is taking place at the North of the country and mostly gull and other water-fowls as crows and birds of prey fall a victims to strikes.Several ornithological station in collaboration with 3000 amateur are creating the maps of migration and at a seasonal bird accumulation;they are carrying out the accounts of the bird number and are evaluating the danger of birds in the area of airports.The utilization of radars is planned for this goals.

The series of Conference reports disclosing interesting peculiarities of bird migrations in various districts of the USSR can be used also to work out measures to prevent bird strkes at concrete airport.

B.Якоб

9. <u>Speech at the closing of the meeting</u>

Gen. Brig. B. Hedberg, Royal Swedish Airforce

Speech at the closing of BSCE/10

Mr Chairman, Gentlemen,

It has been a privilege for us in Sweden to have had the opportunity to host the 10th meeting of Bird Strike Committee Europe.

In Sweden, as well as in most other countries, we have experienced difficulties with collisions between birds and our aircraft. When flying, militarian as well as civilian, our aim is to make as effective a job as possible. All kind of mishaps are drawbacks for the effectiveness. To fly, in general is a difficult task, and requires skillfulness and good responsibility from all persons involved, as well on the operational side as on the technical. Unfortunately, we know, that flying now and then takes its tribute concerning accidents for various reasons. In order to prevent such accidents, there are flight safety organizations in our countries.

In our attempt to solve the flight safety problem concerning bird strikes, I consider the cooperation that takes place within this Committee as a valuable contribution to flight safety. In the Swedish Air Force we are very pleased that it has been possible to establish this cooperation, with the bird hazard problem in focus.

I can tell you that in the Swedish Air Force we already have benefitted from experiences gained during the work of this Committee. It is a real advantage in trying to introduce adequate preventive techniques, to have access to experts' knowledge which we have in the Committee.

With these words I want to thank you for the work you have done and the results you have presented here in Stockholm. I wish the Committee good luck in future work and I hereby declare the official part of the meeting closed. Finaly I hope that you will have a pleasant and well-deserved time during the rest of your stay with us in Sweden.

10. Report on the meeting

Chairman of BSCE, Mr V E Ferry, France

Report on the tenth Meeting of the BSCE
(Stockholm 9 - 13 June 1975)

1. Introduction

1.1 This report is composed of the following three parts:

a) The chairman's Report (Part 1)
b) The report on the work done inside W.G's of BSCE (Part 2)
c) The conclusions resulting from b) (Part 3)

1.2 The chairman's Report, mentioned under a) above, contains a brief description of the proceedings of the Meeting, the organizational and administrative arrangements for the conduct of the Committees business and for its future work.

1.3 The report on the work done inside working groups mentioned under b) above supplements and/or supersedes the previous reports on this subject. It consists of a summary of the points made during the discussion in BSCE W.G's on the subjects treated in the course of the 10th Meeting and as such it serves to support the conclusions reached and the Recommendations which have been formulated by that Meeting.

1.4 The conclusion resulting from this Report, as contained in its Part 3 was reviewed by the Committee during its 10th session, and amended slightly by the chairman for editorial purposes. As a consequence of this, Part 3 is in fact superseding the draft circulated during the meeting, included in this report for information only (Section 1 of the Report refers).

PART 1

CHAIRMAN'S REPORT

1. General

1.1 The Tenth Meeting of the BSCE and its working groups was held from 9 to 13 June 1975 at the Institute of Technology in Stockholm. A list of participants with address is attached in section 2 of the Report.

1.2 At the opening meeting, the BSCE adopted the following agenda:

Item 1: Presentation of papers divided in groups along the analyses shown in section 7, part 7.2.2 of the Report

Item 2: Analysis of the work done by each working group

Item 3: Review of the existing terms of reference of BSCE Committée

Item 4: Review of the existing terms of reference of BSCE W.G'S

Item 5: Review of the need of an Editing Committée

Item 6: Establishment of new working groups

Item 7: Next meeting

Item 8: Any other business

1.3 The meeting was chaired by Mr Ferry elected for a two year period at the end of 9th meeting.

1.4 Mr Turesson and Major Nåsell of Sweden acted as secretaries of the meeting and were charged of the administrative arrangements during the session. Typing and printing was under responsibility of Mrs Lundborg.

2. Administrative arrangement

2.1 The Committee, at the end of the meeting found it necessary to elect a vice chairman. This item will be item 1 of the agenda for 11th meeting BSCE.

3. Proceedings at the meeting

3.1 Discussions on the objects considered by the Committee in accordance with the Agenda are reflected in Part 2 of this report, and the conclusions formulated as a result of these discussions are contained in Part 3.

4. <u>Work programme until the next meeting</u>

4.1 At the end of this meeting, the Committee agreed on the following work programme until the next meeting:

a) Work to be done inside Bird Movement W.G.

I) check if Bird Hazard maps (BSCE/10 WP 30 page 2.3 referring to Annex 15, Appendix 1 and Doc 8126-AN/872/2 Appendix G pages AGA 0.2.1, RAC 6.1 and 6.4 refer) are published by all State members of BSCE,

II) help in providing support for publication to any state which has not been able to publish maps,

III) prepare a revised edition of bird concentration and movement maps already in use,

IV) evaluate the bird risk in large areas in terms of biomass.

b) work to be done inside Communications W.G:

I) test of the circulation of NOTAM dealing with bird movement during the fall migration period as well as the mode of emission of these messages and their use of the addresses, under the same procedure as already used in fall 1974,

II) check and complete if necessary the NOTAM addresses when dealing with birds activities,

III) address to each chairman of National Bird Strike Committee the complete list of NOTAM address for action.

c) work to be done inside Aerodeome W.G.

I) ensure that all information about birds dispersal devices in use in each state are available and prepare a summary for the benefit of various National Bird Strike Committées,

II) collect national regulations applying to garbagedumps and controllable bird movements,

III) study and prepare a document to be used as a check list by airport managers on the devices, their use and remarks made. This document will be a base for a standard to be used of States participating in BSCE.

d) work to be done inside Analysis W.G.

I) insist that all BSCE-states have to use the BSCE-forms for the yearly report of the distribuation of bird strikes recorded by each state (civil and military reports)

II) produce a BSCE bird weight classification to avoid inconsistencies in the national reports

III) continue the special analysis on strikes to engines with an investigation oriented to the ability of intakes and engines to withstand birdstrikes

IV) study the effectiveness of the use of aircraft landing lights for driving birds away from aircraft path

e) work to be done inside Radar W.G.

I) prepare a paper relating to obtained radar birdobservations and bird strike probability

II) explain the feasibility of an automatic warning device to be used on aerodromes when the birds activity if above a given limit

f) work to be done inside Structural Testing W.G.

I) form, elect a chairman and proceed along terms of reference (section 1 para F2 refers)

g) to continue studies aimed at the use of a warning network (combination of radar or visual observation on the spot, NOTAM code, communication system, interpreting center, phraseology to be used by controllers) for aircraft in the vicinity of aerodromes.

h) to continue studies aimed at a uniform method of displaying permanent information in order to obtain a homogeneous coverage of Europe and its immediate vicinity

i) to develop a common basic policy with other organizations in order to standardize BSCE methods (or improved methods) aiming at reducing bird hazard whenever possible

j) to continue studies on the actual cost of bird strikes and the cost effectiveness of the use of aforesaid methods.

4.2 Work on the above subjects was assigned as follows:

a) if not differently stated in the following, work on subject listed on 4.1 from a) to f) is assigned to each W.G´s chairman

b) chairman of BSCE will take part in work assigned in para 4.1 under a) II), b) III), d) I), the work being undertaken primarily by W.G´s chairmen (recommendation D.5, section 1 refers)

c) work on the subject listed under e) I) in para 4.1 to be undertaken by Dr F Hunt (National Research Council, Canada)

d) work on the subject listed under f) in para 4.1 to be undertaken by Mr J Thorpe (U.K.)

5. Arrangements for the next meeting

5.1 The Committee did not develop a specific Agenda for its next meeting because this depends to a considerable degree, on progress achieved by each working group on the work programme outlined in para 4 above.

5.2 It was however agreed, that for the time being, the following points should be retained for possible consideration at the next meeting

a) election of a vice chairman

b) preparing of a generally acceptable document regarding

I) the relation between obtained radar bird observation and bird strike probability

II) a check list for airport managers when a problem dealing with bird activity appears on an aerodrome

III) the evaluation of bird risk in large areas in terms of biomass

IV) the ability of a certain aircraft, or certain parts of an aircraft, to withstand birdstrike

c) the eventual establishment of a working group "as proposed by Dr Hild during the 10th meeting

d) future organization of BSCE (secretariat)

e) presentation of reports for the future BSCE meetings.

5.3 The Committee accepted that the various working groups would present to the Committee reasonably firm proposals on the subjects listed on b) so that, at its next meeting, the Committee would come to firm conclusions.

5.4 As to the subject of working group tasks it is accepted that

I) the W.G. Aerodrome will have its special meetings in airports where the problem of birds is the most severe, in order to help local authorities to select appropriate action

II) the report presented by W.G's chairmen to the Committee will have three sections:

1) review of the work already completed and the last recommendations from the W.G.

2) progress report of the work done during the last year

3) chairman's report on discussions, with conclusions reached

III) the report will be available and circulated before the opening of the plenary session of each BSCE meeting.

5.5 As to the next meeting of the Committee, it was noted that due to a transfer of services, the chairman of the Belgian BSCE is not able to take part in the work of the Committee in 1976. The Netherland delegation was approached and, subject to confirmation, it has been tentatively agreed that the Netherlands will be host for the next meeting, to be held in May-June 1976.

It has been agreed that the 1977 meeting could be held in Belgium and 1978 meeting in Switzerland subject to changes according to circumstances.

6. <u>Acknowledgments</u>

6.1 Lt Colonel Schneider was asked to close the main meeting and give answer to Brigadier General Hedberg (Sw AF). He then announced that he was attending the meeting for the last time due to promotion and new assignment. The Committee expressed hartily its thanks for the eminent work done by Lt Cl Schneider during his chairmanship of BSCE and after when leading the Danish delegation to BSCE.

6.2 The chairman, on behalf of the whole Committee, expressed his gratitude for the impressive and efficient organization of the meeting to all who have contributed to the success of the meeting. It can here be mentioned that all papers (33 WP´s) have been printed and distributed in due time, even when given by their authors at the latest possible time.

For the first time a special "Programme for accompanying persons" was organized and social events were above praise. The concluding remark that the tenth meeting has reached a standard difficult to outsmart was agreed by all members.

PART 2

TENTH REPORT ON THE BSCE ANNUAL SESSION

1. <u>Introduction</u>

1.1 The 10th report on the BSCE annual session relates to the work done inside workinggroups, which assemble at the same time, and by the Committee as a whole when dealing with its specific tasks.

1.2 As all papers presented during the session appear in section 6 of the Report, this report will cover the following subjects:

a) analysis of work done be each workinggroup
b) review of the administrative problems
c) review of actions to be performed following the recommendations
d) special problems

2. <u>Discussion of subjects related to BSCE</u>

2.1.1 Before entering into the discussion of specific items mentioned under para 1.2 above, the Committee felt that a change was needed in the routine of work and in its structure. As a first step it was agreed that an Editing committee must be firmly established and that some changes has to be introducted in the report in order to ease contacts with other International Organizations. The specific points were

a) nature of the Annual Report
b) study of the administrative structure
c) period of meeting and duration.

Although these matters have no direct influence on the work carried out during the session, it has been noted that they should be recorded in a proper way and be part of the Report. They will appear under item b) under para 1.2 above.

2.1.2 Even though the Committee recognized that some short-comings existed in its way to solve problems, it has been felt unnecessary to enter in too abrupt changes without having time to test the validity and the efficiency of the modifications. It was expected that, if still necessary, members would raise this matter again at the next suitable opportunity.

2.2 <u>Reports of working groups</u>

2.2.1 They appear under section 5 of the main Report and are reflecting the nature and specific tasks of each group.

It has been noted that the reports should be presented, whenever possible, under uniform format and type of contents.

2.2.2 Time allowed for this item has not permitted a long discussion. However three points have been realised

a) from W.G. Analysis report: the necessity of a clear definition of "Bird Impact". After a short discussion it has been agreed to use the ICAO definition for the time being:

<u>Confirmed bird strike</u>:

A bird encounter is considered a "confirmed" bird strike if it leaves, on the aircraft concerned, a trace of bird impact, or ingestion into the engine, and this either

a) in the form of damage to the aircraft; or

b) where no damage occurs, a blood smear or bird tissue or feathers visible somewhere on the aircraft.

<u>Note</u>: The above terminology is extracted from ICAO State letter AN 3/32 - 71/150 of 28 October 1971.

b) from W.G. Communications: some reserves have been formulated on the direct use of the NOTAM code for bird activities. One state was still advocating plain language instead of coded messages. A compromise has been reached by the combination of issuing the message in NOTAM groups before the plain language form when a bird warning is issued by this particular state

c) from W.G. Aerodrome: Some states are not answering questionnaires about national regulations on dumps and bird dispersal devices. BSCE chairman has been asked to keep this matter under control.

2.3 <u>Review of Administrative Problems</u>

2.3.1 The Committee has revised its terms of Reference and work program of working groups under BSCE. The revised version appears in section 7 (7.1 for BSCE, 7.3 for work program) of the main Report.

2.3.2 An Editing Committee has been appointed with terms of reference (see section 7.2 main Report) discussed and approved.

2.3.3 The attention has been called to the number of working papers which is steadily increasing. Unless the main Report will be too heavy to be mailed by normal ways, it has been felt necessary that some action should have to be taken. It has been suggested that the Report should have two distinct parts.

a) one more formal being the report on the BSCE work with 3 parts (chairman's report, summary of work, conclusions)

b) the other incorporating papers presented during the meeting.

It has also been suggested that a selection should be made by the Editing Committee, some papers could appear in the main report only in a summary because they should have been subject to discussion inside W.G.

A formal decision has not been reached at the last meeting, so the chairman has been asked to bring up again this problem in a near future.

The main report of the 10th session has been made accordingly.

2.3.4 It has been suggested that the work load could drive to a more permanent structure with a secretariat. A study of that need could be carried out but no final decision has been taken, the majority expressing the view that it was also important that BSCE keep, as long as possible, its benevolent aspect.

2.3.5 It has also been suggested that the plenary sessions of BSCE should be held every two years period, instead of actual practice of having an annual session. As this question was already raised and answered during the 9th meeting, the matter was dropped.

However it has been stressed that a period of 4 days is too short to allow enough time for discussions. This matter will be subject of a longer analysis during the 11th meeting.

2.4 Action to be done

2.4.1 A new working group has been established under the provisional title "Structural Testing".

2.4.2 A proposal for another new group is under consideration.

2.4.3 The chairman of BSCE has been charged to visit all relevant authorities at a convenient level, to obtain better liasion and understanding. It is hoped that some minor problems inherent to national ways of thinking could then be solved.

2.4.4 The chairman has been asked to persue the Committee action with insurance companies and to start action with IATA, the Guild of Air Traffic Controllers and generally all organizations concerned with safety and reliability of air transportation.

2.4.5 Recommendations emerging from the working groups are enclosed in section 1 of the main report.

2.4.6 A special report on the matter of collaboration with ICAO is enclosed in section 8 of the main report.

PART 3

—

Conclusions resulting from the 10th Report

—

1. The time lapse being too short to allow a general consultation on the presentation of this report and the redrafting of recommendations issued by working groups and approved by the committee the only conclusion formulated by the chairman is:

Conclusion 1: That States concerned are once more requested to ensure that methods in use for observing birds, scaring them, reporting their activities etz are fully conformed with ICAO publications and BSCE code of practice formulated in, amongst others, ICAO Aerodrome Manual (Doc 7920.AN/865, Part 5, vol II refers) and BSCE Reports (see WP 5A, 5B as an illustration).

297